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PROBLEMS OF THE GEOGRAPHIC AND STRATIGRAPHIC DISTRIBUTION OF AMERICAN MIDDLE EOCENE LARGER FORAMINIFERA

By

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and

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January 17, 1964

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PROBLEMS OF THE GEOGRAPHIC AND STRATIGRAPHIC DISTRIBUTION OF AMERICAN MIDDLE EOCENE LARGER FORAMINIFERA[1,2]

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and
Esther R. Applin
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ABSTRACT

Larger Foraminifera from the middle Eocene of Florida and southern Georgia are discussed, including two new species, and their geographic and stratigraphic distribution, not only in the United States, but also at selected localities in the Caribbean Region, is analyzed. Several species not previously reported from the United States are discussed and illustrated. Analysis of the larger Foraminifera suggests that the Inglis limestone can not be separated from the underlying Avon Park limestone and represents the upper part of the Avon Park limestone. The *Helicostegina gyralis* zone (uppermost zone) of the Oldsmar limestone (lower Eocene) is transferred to the basal Lake City limestone (middle Eocene).

INTRODUCTION

Cushman (1919, p. 77; 1921, p. 33) was one of the first to discuss middle Eocene larger Foraminifera from wells in Florida, but he misidentified *Dictyoconus* as *Orbitolina*. Therefore, he considered that most of the sediments, assigned later to the middle Eocene, were Early Cretaceous in age. Vaughan (1923, p. 254) correctly identified these specimens as *Dictyoconus* and stated, "There is no known evidence of deposits of Lower Cretaceous age occurring at relatively shallow depths in Florida, the deposits considered by Cushman as of Lower Cretaceous age being, according to the material I have examined, of either Oligocene or Eocene age."

Later, Cushman (1927, p. 198) wrote " . . . a more careful study of species of *Orbitolina* and of sections of the Florida specimens has convinced me that the determination of the latter as *Orbitolina* was incorrect and that the beds containing them are of Middle Eocene age." Cooke and Mossom (1929, p. 46) in their *Geology of Florida* did not attempt to subdivide the Eocene. They stated "It is now supposed that the Eocene limestone is several hundred feet thick and that it is underlain by Upper Cretaceous sediments . . . "

In 1934 Cole and Ponton described *Asterocyclina monticellensis*, *Fabularia vaughani*, and *Lepidocyclina ariana* from samples from wells in Florida, but they did not specify that these species were obtained from

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[1] Publication authorized by the Director, U.S. Geological Survey.

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middle Eocene sediments. In 1938 almost simultaneously Gravell and Hanna (pp. 1007, 1010) and Cole (pp. 21, 22) published records of the occurrence of *Lepidocyclina* (*Polylepidina*) *gardnerae Cole* (=*L. antillea* Cushman), and the *Discocyclina blanpiedi* Vaughan (= *Discocyclina weaveri* Vaughan)—*Discocyclina cookei* Vaughan [= *Pseudophragmina* (*Athecocyclina*) *stephensoni* (Vaughan)] fauna from the Granberry well No. 1 in Jackson County, Florida. Thus, records were definitely established of the occurrence in western Florida of species which elsewhere on the Gulf Coastal Plain of the United States characterized the Claiborne and Wilcox.

In peninsular Florida Stubbs (1937, p. 27) tentatively referred a subsurface limestone to the upper part of the middle Eocene, basing this suggestion on Mrs. Applin's opinion that " . . . this limestone is probably Upper Claiborne in age." However, the first detailed descriptions of species in peninsular Florida from middle Eocene limestones were the ones by Cole (1941; 1942). He (Cole, 1941, p. 7) suggested that "This section represents the middle Eocene. It is the probable equivalent of the Claiborne section reported from the Granberry Well." Elsewhere in this same bulletin Cole (1941, p. 16) wrote: "This limestone may be the deeper water equivalent of the sands described in the paper on the Granberry well (W-285) and assigned to the Claiborne."

Later, Cole (1944, p. 25) established the presence of the *Lepidocyclina* (*Polylepidina*) *antillea* zone, previously recognized in western Florida, in a well in northeastern Florida and discussed other middle Eocene larger foraminiferal zones found in this same well.

The Applins in 1944 published a comprehensive article on the subsurface stratigraphy and structure of Florida and southern Georgia in which for the first time formational designations were given to the middle Eocene subsurface units. They proposed that the beds of middle Eocene age below the Ocala limestone (upper Eocene) be named from youngest to oldest, Avon Park limestone, Tallahassee limestone, and Lake City limestone. In 1945 E. R. Applin and Jordan reviewed many of the diagnostic Foraminifera from subsurface formations in Florida and described several new species.

Bermudez (1950) was the first to suggest the correlation of Floridian formations with those of Cuba. Cole and Gravell (1952, p. 709), in discussing larger Foraminifera collected from the lowest 6 inches of strata exposed in an abandoned pit near Peñon, Matanzas Province, Cuba, demonstrated that many of the species which occurred in Florida in separate and stratigraphically separated zones were associated in Cuba.

Since then information has been published on middle Eocene foraminiferal faunas of Mexico, St. Bartholomew, Jamaica, Cuba, and Venezuela. An attempt will be made in this article, not only to review and describe species from the middle Eocene of Florida and adjacent parts of Georgia, but also to correlate the occurrences of these species with selected localities elsewhere in the Caribbean region.

Certain postulates made here concerning interregional correlations are based upon the insufficiently known stratigraphic ranges of many of the species and may be incorrect. However, the statement of the problems may focus attention upon them so that ultimately a correct solution will be found.

The types and other specimens will be deposited in the U. S. National Museum.

LOCALITIES

Florida

Columbia County

Loc. 1—City well, Lake City (Fla. Geol. Sur. No. W-299), Sec. 5, T. 4 S., R. 17 E.

Duval County

Loc. 2—City of Jacksonville (Fla. Geol. Sur. No. W-322) in south Jacksonville, River Oaks Pump Station, Sec. 25, T. 2 S., R. 26 E.

Loc. 3—City of Jacksonville, well No. 22 (Fla. Geol. Sur. No. W-541) Day Street, Jacksonville, Sec. 13, T. 2 S., R. 26 E.

Loc. 4—City of Jacksonville well (Fla. Geol. Sur. No. W-579) at intersection of Fifth and Hogan Streets, Sec, T. 2 S., R. 26. E.

Loc. 5—St. Johns Ship Building Company well (Fla. Geol. Sur. No. W-649), Jacksonville, 1¼ mi. east of Post Office, Sec. 18, T. 2 S., R. 27 E.

Franklin County

Loc. 6—The California Co.—Coastal Petroleum Co., State Lease 224-A, well No. 2 (Fla. Geol. Sur. No. W-5654), Latitude 29° 47′ 03″ N, Longitude 84° 22′ 51″ W. Offshore about 6 mi. south of Lighthouse Point, Franklin County, Fla.

Monroe County

Loc. 7—Florida East Coast Railway well at Marathon (Fla. Geol. Sur. No. W-2), Key Vaca, Sec. 9, T. 66 S., R. 32 E.

Loc. 8—Peninsular Oil and Refining Company, J. W. Cory well No. 1 (Fla. Geol. Sur. No. W-445) near Pinecrest, Sec. 6, T. 55 S., R. 34 E.

St. Johns County

Loc. 9—Florida East Coast Hotel Company, Ponce de Leon Hotel well (Fla. Geol. Sur. No. W-236), Sec. 18, T. 7 S., R. 30 E.

Walton County

Loc. 10—Oil City Corporation, Walton Land and Timber Company well No. 1, (Fla. Geol. Sur. No. W-148), Sec. 12, T. 1 N., R. 19 W.

Loc. 11—Sun Oil Company, Brady Belcher well No. 3, Sec. 33, T. 4 N., R. 21 W.

Georgia

Clinch County

Loc. 12—Wiley P. Ballard, Jr., Timber Products Company well B-1, Land Lot 306, Land District 7.

Pierce County

Loc. 13—Pan-American Production Co. Adams-McCaskill well No. 1, (Ga. Geol. Sur. No. 119), Land Lot 329, Land District 4.

Jamaica

Loc. 14—One-half mile southwest of Sandy River, Clarendon; H. R. Versey, collector.

Loc. 15—About one mile northwest of Port Maria, St. Mary's Parish; E. Robinson, collector.

France

Loc. 16—Calcaires de St. Palais, at St. Palais (Le Bureau) in cliff along seaside walk, near Royan, Charente Maritime; H. T. and A. R. Loeblich, Jr., collectors, 26 January 1954.

RELATIONSHIP OF FACIES TO THE DISTRIBUTION OF LARGER FORAMINIFERA

Regionally, there are two distinct faunal provinces of larger Foraminifera in the middle Eocene in the southern part of the United States. Under most of peninsular Florida the middle Eocene is represented by massive limestones and dolomites in which the characteristic genera are *Lituonella, Coskinolina, Dictyoconus, Gunteria,* and others. This limestone facies usually does not have *Lepidocyclina, Pseudophragmina,* or *Camerina* present.

Westward, from Alabama to Texas and the Tampico Embayment area the middle Eocene is represented by a clastic facies in which *Lepidocyclina. Pseudophragmina,* and *Camerina* occur, but genera common in the limestone facies of peninsular Florida have not been found.

In northern Florida and southern Georgia in a zone in which the limestone and clastic facies interfinger, species characteristic of both the limestone and clastic facies occur. Certain of these species may be grouped together in single samples, or more often only a single species may be found at a given stratigraphic horizon.

The occurrence of the genera and species within these two major facies seemingly is the result of ecological controls. *Dictyoconus,* for example, not only survived in the limestone facies of peninsular Florida but in places flourished so abundantly that its tests comprise large parts of the limestone. *Lepidocyclina,* on the other hand, became established only in clastic sediments or in marly limestones. However, *Lepidocyclina* was more tolerant as specimens do occur in marly limestone, whereas *Dictyoconus* appears to be restricted to limestones.

Any attempt to correlate the larger foraminiferal faunas of the limestone facies of peninsular Florida with those of the clastic facies of the Gulf Coast westward from Alabama must be based upon an analysis of the faunas in northern Florida and southern Georgia where the faunas of these two distinct facies interfinger.

Correlation is, moreover, complicated by lack of data concerning the method, route, and time of migration of the benthonic larger Foraminifera. Cole (1960, p. 15) postulated that larger Foraminifera are distributed by floatation in masses of vegetation which were separated from the substratum by large storm waves. He (Cole, 1960, p. 16) wrote regarding this method of distribution: "The migration of the larger Foraminifera would be slow, erratic, and discontinuous. Moreover, under the conditions proposed genera might not be transported to a favorable situation where a colony could be established."

However, if such accidental migrants find suitable ecological conditions which are extensive geographically, they seemingly spread rapidly over the entire suitable area and are checked in their spread only where unsuitable conditions are encountered. Thus, these accidental migrants become rapidly widespread within a given ecological province.

Moreover, a species once established, if ecological conditions continue to be favorable, may range through a relatively thick stratigraphic section.

Gravell and Hanna (1938, p. 1008) reported that the *Lepidocyclina* (*Polylepidina*) zone " . . . has been found in a few wells through a section of as much as 200 feet." If local ecological conditions were unfavorable, specimens of *Lepidocyclina* (*Polylepidina*) would not be found even in wells near one in which the thick zone was encountered. In other adjacent wells specimens of *Lepidocyclina* (*Polylepidina*) might be found in a single sample, thereby giving the impression that this zone was extremely thin.

In certain cases genera or species may be introduced into an area, survive for a limited time, and disappear. Yet, in other areas under more favorable ecological conditions these same genera and species may flourish for longer periods of time. Thus, the stratigraphic range of genera and species may be different within the same geographic province depending upon the ecological conditions.

Moreover, it may be postulated that during the middle Eocene northern Florida and southern Georgia were at or near the temperature limit at which genera of larger Foraminifera could survive. This would be, therefore, a geographic area in which extreme fluctuations both of colonization and maintenance of populations would occur.

Evidence is accumulating to suggest that under optimum conditions certain species of larger Foraminifera formerly thought to have rather narrowly restricted stratigraphic ranges may have extended stratigraphic ranges. Cole (1958*b*, p. 262; 1958*c*, p. 417) demonstrated that species of camerinids and discocyclinids, formerly thought to be restricted to the middle or upper Eocene, range from middle into upper Eocene.

Helicolepidina spiralis Tobler is known to range from middle into the upper Eocene (Cole, 1962). At locality 15 (Jamaica) *H. spiralis* occurs with *Lepidocyclina* (*Polylepidina*) *antillea* (Cushman), a species which in Florida and elsewhere on the Gulf Coast of the United States is restricted to the middle Eocene. In Florida, however, *Helicolepidina spiralis* has been reported only from the uppermost Eocene where it is associated with *Lepidocyclina* (*Eulepidina*) *chaperi* Lemoine and R. Douvillé (Moore, 1955, p. 38).

Helicolepidina is a distinctive and easily recognized genus which has been reported from many middle and upper Eocene localities in Trinidad, Venezuela, and Panama, yet in the southern United States it is known only from a deep well in Louisiana (Vaughan, 1936) and from a few surface samples in northwestern Florida.

Although *Discocyclina* (*Discocyclina*) occurs abundantly in the Eocene of Cuba and Trindad, it has not been found in Georgia until two species were found in the present collection. These occurrences establish the fact that *Discocyclina* (*Discocyclina*) did migrate from areas where it was well established but seemingly did not successfully colonize for any length of geologic time the marginal areas into which it migrated.

CORRELATION BY LARGER FORAMINIFERA

In the limestone sections penetrated by wells in Florida and Georgia the larger Foraminifera are often the most easily recognized of the fossils recovered. Therefore, it has been logical to base stratigraphic determinations upon the occurrences of these organisms, supplemented in every case possible by an analysis of the associated smaller Foraminifera or other groups of organisms.

If the conditions of deposition were uniform within a given area, subdivision and correlation may be useful and practical using larger Foraminifera. It must be appreciated, however, that correlation between provinces in which different conditions of deposition prevailed may be difficult, and the ranges of species may vary from province to province.

Moreover, species which in one province occur in association in single samples may be separated from each other in another province by a considerable stratigraphic interval. Thus, in one province several species may be considered to be characteristic of a stratigraphic zone, but in another province these same species may be considered to be stratigraphic markers for several distinct and stratigraphically separated zones.

Cole (1942, p. 7) zoned a part of the middle Eocene of Florida recognizing five zones based mainly upon the occurrence of single species at different stratigraphic levels. The Applins (1944, p. 1678, Table 1) and E. R. Applin and Jordan (1945), although maintaining zones based upon single species, broadened correlation by combining zonal species into faunas of formations. Thus, species would be diagnostic of a formation covering a considerable stratigraphic interval rather than markers for limited stratigraphic zones within a given formation.

As Cole and Gravell (1952, p. 710) demonstrated, several species in Florida, which had been used either as zonal markers or as being diagnostic of formations, occur together within one six-inch thick layer at Peñon Seep, Matanzas Province, Cuba. Therefore, if larger Foraminifera are used for correlation between separate provinces, an adequate explanation for these differences of association and stratigraphic position must be stated as we have attempted to do in the preceding section.

LARGER FORAMINIFERA AS FORMATIONAL INDICES

Although Cole (1941, pp. 7, 16) and the Applins (1944, p. 1678, Table 1) placed the top of the middle Eocene upon the first appearance in wells of such characteristic species as *Lituonella floridana, Dictyoconus floridanus* (=*Coskinolina floridana*), *Discorinopsis gunteri,* and others, this decision has been challenged.

Bermudez (1950, p. 248) correlated the Avon Park limestone with the Jabaco formation, stating that the most important species common to both formations were *Lituonella floridana* and *Dictyoconus floridanus* (=*Coskinolina floridana*). The Jabaco formation is considered by Bermudez to be lower upper Eocene in age.

On the other hand Katherine V. W. Palmer (in Richards and Palmer, 1953, p. 9) stated "The evidence of the identifiable gastropods corroborates a middle Eocene or Lutetian age of the Avon Park limestone . . . "

Dictyoconus floridanus, Discorinopsis gunteri, Lituonella floridana, Pseudochrysalidina floridana, and *Spirolina coryensis* in Florida are characteristic markers for the Avon Park limestone (upper middle Eocene), but they have not been reported from the Ocala limestone (upper Eocene). In Trindad (Vaughan and Cole, 1941) and in Panama (Cole, 1952) they do not occur in the upper Eocene although numerous samples have been examined.

In Cuba (Bermudez, 1950, p. 248) and Jamaica (Cole, 1956, Table 5) certain of these species, but not all, have been reported from samples assigned to the upper Eocene. These samples in which middle Eocene species occur should be reexamined as they may have been improperly assigned to the upper Eocene.

However, such species, as *Fabiania cassis* and *Lepidocyclina pustulosa,* definitely range from the middle into the upper Eocene. Thus, there is the possibility that species, such as *Dictyoconus floridanus, Lituonella floridana,* and others, have more extensive ranges in other geographic areas than study of wells in Florida would indicate.

Moreover, the possibility of reworking must not be ignored. It has been well established (Cole and Bermudez, 1947, p. 192) that Upper Cretaceous larger Foraminifera have been reworked into the Eocene in Cuba.

Vernon (1951, p. 115) defined as the Inglis member of the Moodys Branch formation the basal part of strata which Applin and Jordon (1945, p. 130) discussed as "the lower member of the Ocala limestone" and also included in this unit the upper part of strata in wells which Cole (1942, p. 6) and the Applins (1944, p. 1752, fig. 37) considered to be middle Eocene in age.

Puri (1957, p. 24) raised the Inglis member to formational rank and presented (p. 29) a chart showing the ranges of Foraminifera and Ostracoda in the Inglis limestone and the Williston formation of Vernon (1951). Puri (1957, p. 50) remarked concerning the distribution of certain of the Foraminifera and Ostracoda "all these forms were originally described from the middle Eocene, but are also abundant in the Inglis formation. The fauna of the Inglis formation is transitional between the middle and the upper Eocene . . . "

Moreover, there does not seem to be agreement concerning the stratigraphic ranges of certain species. Vernon (1951, p. 118) wrote concerning the fauna of the Inglis: "Only one large Foraminifera, *Camerina vanderstoki* (Rutten and Vermunt), is present and it is limited to the upper few feet." On the other hand Puri (1957, p. 180) recorded *Nummulites vanderstoki* (=*Camerina striatoreticulata*) as occurring only in the upper Williston formation and in the Crystal River formation of Puri (1953).

If the distributional lists of Foraminifera, especially the larger and distinctive species, such as *Discorinopsis gunteri, Spirolina coryensis,* and others, given by Vernon (1951, Table 10) and Puri (1957, Table 1) are analyzed, the major break in faunal sequences occurs at the top of the Inglis.

Richards and K. V. W. Palmer (1953, p. 59) in their well-organized discussion of the molluscan fauna reached two conclusions: 1) "The study of the gastropods and pelecypods from the Avon Park limestone supports the view that this formation is of middle Eocene (Lutetian) age; 2) The fauna from the Inglis member of the Moody's Branch formation shows a strong affinity with the middle Eocene (Lutetian=Claiborne), as well as with the upper Eocene (Jackson). It is probable that the age of the Inglis is lower Jackson, as suggested by Vernon (1951, p. 112)."

Although more data are necessary for a complete understanding of the geographic and stratigraphic distribution of the Foraminifera, there is more information available concerning these organisms than there is concerning the Mollusca. If the Foraminifera alone are considered, the major discontinuity in foraminiferal faunas occurs between the Inglis and the Williston.

The foraminiferal faunas of the Lake City, Avon Park, and Inglis are essentially a unit in peninsular Florida composed of such genera, as *Lituonella, Dictyoconus, Spirolina,* and *Fabularia.* The fauna of the overlying Ocala limestone lacks these genera and consists of *Camerina, Lepidoclina, Asterocyclina,* and *Pseudophragmina.*

As the major break in foraminiferal faunas occurs at the top of the Inglis, and as we can not discover any criteria in continuous sections of well samples whereby the Inglis could be separated from the Avon Park, in the authors' opinion, the Inglis should be abondoned and these strata included in the Avon Park limestone. Thus, the stratigraphic order would be the same as that proposed by the Applins (1944).

Although Richards and Palmer (1953, p. 59) stated the probable age of the Molluscan fauna of the Inglis is lower Jackson, they emphasized that this fauna has " . . . a strong affinity with the middle Eocene . . . " As the Foraminifera are the same kinds that occur throughout the strata which underlie those from which the Mollusca were obtained, we consider that the evidence is such that this entire section which we refer to the Avon Park limestone is middle Eocene in age.

As Cole (1942, p. 13) as early as 1942 pointed out, the " . . . faunas of the middle Eocene of peninsular Florida more nearly resemble those of Mexico and the West Indian region than those of the Gulf Coast of the United States." Later, Richards and Palmer (1953, p. 59) reemphasized this origin of the faunas of peninsular Florida by stating "The discovery of the unusual Avon Park and Inglis faunas in Florida strongly suggest an extension of the Tethyan fauna from the West Indies to Florida." The final solution to the correlation of the middle Eocene of peninsular Florida may be found when the sequences in Cuba are known in detail.

The problem of selecting a guide fossil or fossils to distinguish the top of the Oldsmar limestone (Wilcox equivalent, lower Eocene) from the base of the overlying Lake City limestone (middle Eocene) by Foraminifera is even more difficult than deciding upon the indices for the top of the middle Eocene.

The Applins (1944, p. 1699) chose for the top of the Oldsmar limestone " . . . the presence of abundant specimens of *Helicostegina gyralis* Barker and Grimsdale . . ." There is no question that the *H. gyralis* zone is present in numerous wells, or that it occurs below such characteristic

Lake City species as *Dictyoconus americanus, Lepidocyclina antillea,* and others in Florida. However, the Applins (1944, p. 1693) suggested that the *H. gyralis* zone might eventually prove to be basal middle Eocene in age.

The difficulty of using *H. gyralis* arises when its occurrence elsewhere in the Caribbean Region is examined. The types of *H. gyralis* are from beds referred by Barker and Grimsdale (1936, p. 237) to " . . . the top of the lower or the base of the middle Eocene . . . " Later, Barker and Grimsdale (1937, p. 173) found *H. gyralis* in association with *Pseudolepidina trimera* in beds which they stated are known " . . . to be near the base of the middle Eocene."

Cole and Gravell (1952, p. 713) reported *H. gyralis* from Cuba where it occurs with such distinctive species as *Gunteria floridana* in a bed assigned to the middle Eocene. In Jamaica (Cole, 1956, Table 4) *H. gyralis* was found in strata assigned to the middle Eocene, and in St. Bartholomew (Cole, 1958*a*, p. 190) it occurred with *Lepidocyclina* (*Polylepidina*) *antillea.*

As *H. gyralis* has not been reported from elsewhere in the Caribbean Region below the base of the middle Eocene, the suggestion is made that the *Helicostegina gyralis* zone be included in the basal part of the Lake City limestone. If this suggestion is followed, the index species for the top of the Oldsmar limestone would be *Pseudophragmina* (*Proporocyclina*) *zaragosensis* (Vaughan) (=*P.* (*P.*) *cedarkeysensis* Cole).

Coskinolina elongata Cole occurs in Florida (Applins, 1944) in several wells either below the first occurrence of *Pseudophragmina* (*Proporocyclina*) *zaragosensis* (Vaughan), or, where that species is absent, at the top of the Oldsmar limestone as redefined in this bulletin.

In Jamaica *C. elongata* occurs with *Fabularia matleyi* (Vaughan) and *Coskinolinoides jamaicensis* Cole (1956, Table 4) in strata which are assigned to the base of the "yellow" limestone (Hose and Versey, 1956, Text-fig. 1). *Coskinolinoides jamaicensis* has not been reported from Florida. *Fabularia matleyi* in Florida ranges through the Lake City and Avon Park limestones, and *Coskinolina elongata* is known only from the Oldsmar limestone.

These data suggest that *Fabularia matleyi* has a long stratigraphic range from lower through the middle Eocene, and that there is the possibility that the basal part of the "yellow" limestone may be lower rather than middle Eocene in age.

Obviously, however, this is another case in which more data must be obtained before exact correlation can be made between Florida and localities elsewhere in the Caribbean region.

Table 1 gives the distribution of selected species from the limestone facies (Lake City limestone) of peninsular Florida, and Table 2 shows the distribution of selected species from the clastic facies of northern Florida and southern Georgia. *Lepidocyclina cedarkeysensis* (=*L. pustulosa*) has been reported from wells in both facies and serves to interrelate these two tables. All the depths given represent the depth of the first reported occurrence of the species as the samples were examined downward from the well mouth. Table 3 records the species of larger Foraminifera found in samples from wells in Duval and Columbia Counties, Florida.

There appears to be order in the occurrences of these species in spite of certain irregularities. The basal part of the Lake City limestone (limestone facies) has as characteristic fossils *Amphistegina parvula* (Cushman), *Gunteria floridana* Cushman and Ponton, and *Helicostegina gyralis* Barker and Grimsdale (see Table 1). *Lepidocyclina* (*Polylepidina*) *antillea* Cushman and *Camerina willcoxi* (Heilprin) (Table 2) occur above this basal zone and are best developed in the clastic facies of the Lake City formation. These species, however, if they occur in peninsular Florida, have not been reported.

The uppermost zone of the clastic and limestone facies of northern Florida is characterized by the occurrence of *Asterocyclina monticellensis* Cole and Ponton, *Lepidocyclina* (*Lepidocyclina*) *ariana* Cole and Ponton, and *L.* (*L.*) *pustulosa* H. Douvillé (Table 2).

Above these three broad zones, and developed only in the limestone facies, another zone occurs characterized by *Dictyoconus floridanus* (Cole), *Discorinopsis gunteri* Cole, *Lituonella floridana* Cole, *L. grandicamerata,* n. sp., and *Spirolina coryensis* Cole. This zone is the Avon Park limestone.

Species, such as *Fabularia matleyi* (Vaughan), range from the uppermost zone of the Lake City into the Avon Park limestone. Other species, such as *Dictyoconus americanus* (Cushman), seemingly have less extended ranges, but this species ranges at the minimum from the *Lepidocyclina antillea* zone throughout the uppermost zone of the Lake City limestone.

However, the species which seemingly have the shortest stratigraphic ranges appear in stratigraphic order, and may be used not only for cor-

Table 1—Depths (feet) of occurrence of selected species from the Lake City limestone (after Applins, 1944)

	1	2	3	4	5	6	7	8
Dictyoconus americanus (Cushman)	811	590	890	——	525*	945	915	1540
Lepidocyclina pustulosa H. Douvillé	833	925	——	——	——	990	915	——
Linderina floridensis Cole	983	——	1145	——	——	——	915	1790
Gunteria floridana Cushman and Ponton	983	1225	1170	1930	1064	——	——	——
Amphistegina parvula (Cushman)	1301	925	1281	——	——	1285	——	1880
Helicostegina gyralis Barker and Grimsdale	1308	1350	1430	2165	1085	1480	——	1960

*First sample

1. Florida Oil and Development Company Sholtz well No. 2, Levy County, Fla.
5. Florida Oil and Development Company, Putnam Lumber Company well No. 1,
3. Dundee Petroleum Company "Bushnell well," Sumter County, Fla.
4. R. V. Hill's "Oldsmar well," Hillsborough County, Florida.
5. Florida Oil and Development Company, Putnam Lumber Campany well No. 1, Dixie County, Florida.
6. St. Mary's River Oil Corporation, Hilliard Turpentine Company well No. 1, Nassau County, Florida.
7. J. S. Cosden's W. L. Lawson well No. 1, Marion County, Fla.
8. Pioneer Oil Company, Hecksher-Yarnell well No. 1, Polk County, Fla.

relation within a limited geographic area, but also for broad correlations between different areas.

CORRELATION WITH CARIBBEAN LOCALITIES

Table 4 lists 11 characteristic species of the Lake City limestone and six species from the Avon Park limestone. Nine of these 17 species occur in association in a six-inch thick layer at Peñon Seep, Matanzas Province, Cuba (Cole and Gravell, 1952, p. 710). Six of the species have been recorded thus far from the middle Eocene of St. Bartholomew and nine from Jamaica. Four species occur at all of the localities.

Three of the nine species common to Florida and Peñon Seep, Cuba, occur in the Avon Park limestone and six occur in the Lake City limestone. The Peñon Seep locality is assigned by Bermudez (1950, p. 240) to the Loma Candela formation of middle Eocene age and is correlated

Table 2—Depths (feet) of occurrence of selected species from the clastic and limestone facies equivalent to the limestone facies of the Lake City limestone (after Applins, 1944)

	1	2	3	4	5	6	7
Fabularia matleyi (Vaughan)	——	1260	1005	1740	——	——	1757
Lepidocyclina ariana Cole and Ponton	——	1260	1065	1740	——	——	1757
pustulosa H. Douvillé	——	1260	990	——	——	——	——
Asterocyclina monticellensis Cole and Ponton	——	1880	1198	1740	——	——	1757
Lepidocyclina antillea Cushman	220	2010	1245	1740	755	645	——
Camerina willcoxi (Heilprin)	220	1580	1140	——	755	645	——

1. Hammond's Granberry well No. 1, Jackson County, Fla.
2. California-Coastal No. 2, State Lease 224-A, St. George Sound, Franklin County, Florida (loc. 6 of this article).
3. St. Mary's River Oil Corporation, Hilliard Turpentine Company well No. 1, Nassau County, Fla.
4. Southern States Oil Corporation, Miller and Gossard well No. 1, Jefferson County, Fla.
5. Oil City Corporation, Walton Land and Timber Company well No. 1, Walton County, Fla.
6. Escambia Oil Campany, State Line Land and Timber Company well No. 1, Escambia County, Alab.
7. Brown and Ravlin, V. G. Philips well No. 1, Wakulla County, Fla.

by him with the Lake City limestone and the Cook Mountain formation of Claiborne age.

If the three species, *Dictyoconus walnutensis, Discorinopsis gunteri,* and *Spirolina coryensis,* found at Peñon Seep and in the Avon Park limestone of Florida, are considered to be migrants into Florida later than the other species, the Peñon Seep locality would correlate approximately with the middle, or *Lepidocyclina antillea* zone, of the Lake City limestone. This postulate is based upon the occurrence at Peñon Seep of *Helicostegina gyralis* and *Gunteria floridana* of the lower Lake City zone and *Asterocyclina monticellensis* of the upper Lake City zone.

In addition, *Pseudophragmina* (*Proporocyclina*) *flintensis* occurs at Peñon Seep. This species is recorded from the Cook Mountain of Texas, the Guayabal formation of Mexico, and in Jamaica (see faunal list of loc. 15) often in association with *Lepidocyclina antillea.*

Table 3—Occurrence of species in well samples from Duval and Columbia Counties, Florida

Locality*	Duval Co.			Columbia Co.	
Depth (ft.)	2	3	4	5	1
	895-905	1165-1180	1220-1230	825-835	610-628
Amphistegina parvula (Cushman)			X		
Camagueyia perplexa Cole and Bermudez	X				X
Dictyoconus americanus (Cushman)	X	X			X
floridanus (Cole)				X	X
Fabiania cassis (Oppenheim)		X			
Fabularia matleyi (Vaughan)	X			X	X
Lepidocyclina (*Lepidocyclina*) *pustulosa* H. Douvillé		X	X		X
(*Polylepidina*) *antillea* Cushman		X			
Lituonella floridana Cole				X	X
L. grandicamerata, n. sp.				X	X
Pseudochrysalidina floridana Cole				X	
Spirolina coryensis Cole				X	

*See Introduction—Localities

Beckmann (1958, p. 418) found seven species of planktonic Foraminifera in association with the larger Foraminifera at Peñon Seep, Matanzas Province, Cuba. He correlated this locality with the *Hantkenina aragonensis* zone of lower middle Eocene age and stated "This places the fauna of Peñon Seep just below the first occurrence of *Lepidocyclina* . . ."

However, of the seven species which he listed, only *Globorotalia pseudomayeri* Bolli is known to date to be confined to this zone. The Peñon Seep locality might be equivalent to the *Globigerapsis kugleri* zone as the range of this one species could be more extensive than data available indicate.

Beckmann (1958, p. 420) identified specimens of *Lepidocyclina* (*Polylepidina*) *antillea* as occurring in Cuba " . . . in the upper part of the *Globigerapsis kugleri* zone and in the lower part of the *Globorotalia lehneri* zone." Although *Lepidocyclina* (*Polylepidina*) has not been reported from Peñon Seep, species of larger Foraminifera, such as *Pseudophragmina flintensis* and *Asterocyclina monticellensis*, do occur there. As

Table 4—Occurrence of Lake City and Avon Park limestones species at selected Caribbean localities

	Cuba(1)	St. Bartholomew(2)	Jamaica(3)
Lake City limestone			
Amphistegina parvula (Cushman)	P.S.	X	
Asterocyclina monticellensis Cole and Ponton	P.S.	X	X
Camagueyia perplexa Cole and Bermudez	L.		X
Dictyoconus americanus (Cushman)	P.S.	X	X
Fabiania cassis (Oppenheim)	P.S.	X	X
Fabularia matleyi (Vaughan)			X
Gunteria floridana Cushman and Ponton	P.S.		
Helicostegina gyralis Barker and Grimsdale	P.S.	X	X
Lepidocyclina antillea Cushman		X	X
pustulosa H. Douvillé	L.(?)		
Linderina floridensis Cole			X
Avon Park limestone			
Dictyoconus floridanus (Cole)	J		
walnutensis (Carsey)	P.S.		
Discorinopsis gunteri Cole	P.S.		
Lituonella floridana Cole	J		
Pseudochrysalidina floridana Cole			X
Spirolina coryensis Cole	P.S.		

(1)Cole and Gravell, 1952, p. 710; P.S. = Peñon Seep; L. = Loma Candela formation; J = Jabaco formation.
(2)Cole, 1958*a*, p. 190.
(3)Cole, 1956, Table 4; see also this article under *L. antillea*.

these species are associated with *Lepidocyclina* (*Polylepidina*) *antillea* elsewhere, we suggest that Peñon Seep might as reasonably be correlated with the *Globigerapsis kugleri* zone of Trinidad.

The zone of *Lepidocyclina antillea* in the Lake City limestone correlates with the *Lepidocyclina antillea* zone of Jamaica (Hose and Versey, 1956, p. 23). They wrote (p. 31): "The upper yellow Limestone belongs in the *L. antillea* zone," and on page 32 stated "The foraminifera occurring in the limestones here are *Yaberinella jamaicensis, Linderina floridensis* Cole, *Fabiania cubensis,* a wide variety of *Lepidocyclina antillea, Borelis* cf. *jamaicensis,* and an undetermined nummulitid." The specimens identified as *Borelis* cf. *jamaicensis* are *Fabularia matleyi.*

The St. Bartholomew limestone of St. Bartholomew correlates with the *Lepidocyclina antillea* zone of the Lake City limestone, but the uppermost zone of the Lake City limestone has not been reported from St. Bartholomew.

STRATIGRAPHIC POSITION OF SPECIES NOT PREVIOUSLY RECORDED FROM FLORIDA AND GEORGIA

Discocyclina (*Discocyclina*) *marginata* (Cushman) from locality 12, Pierce County, Georgia, occurs at Peñon Seep, Matanzas Province, Cuba (Cole and Gravell, 1952, p. 714), and at numerous other Cuban localities, in the St. Bartholomew limestone (Cole and Gravell, 1952, p. 715, pl. 93, fig. 2), and in Barbados (as *D.* (*D.*) *harrisoni*). The age is middle Eocene.

Pseudophragmina (*Proporocyclina*) *teres* Cole and Gravell occurs at localities 12, Clinch County and 13, Pierce County, Georgia, in association with *Lepidocyclina antillea.* This species was described from Peñon Seep, Matanzas Province, Cuba (Cole and Gravell, 1952, p. 725), in association with *Gunteria floridana* and many other species, and later (Cole, 1958*a*, p. 190) was found in the St. Bartholomew limestone. The association of species suggests that *P.* (*P.*) *teres* may be another marker for the *Lepidocyclina antillea* zone of the Lake City limestone.

Pseudophragmina (*Proporocyclina*) *tobleri* (Vaughan and Cole) found at localities 10 and 11, Walton County, Florida, is known elsewhere only from Soldado Rock, Trinidad. Cole (1959, p. 381) wrote concerning the occurrence in Trinidad "Thus, the *P.* (*P.*) *tobleri* zone may be assigned provisionally to the middle Eocene."

The Applins (1944, p. 1742, fig. 27) considered the section of the well (loc. 10) at which *P.* (*P.*) *tobleri* occurred at 1752 feet to be in "Beds of Wilcox age" (lower Eocene), and represented the "Top of the Salt Mountain." Although the assignment of these beds to the lower Eocene may be correct, they also might be lower middle Eocene in age. There are not sufficient data available as yet to be absolutely certain. However, it is extremely doubtful if the strata at this depth are equivalent to the Salt Mountain limestone.

P. (*P.*) *tobleri* occurs at locality 11 in this same county (Walton) at a depth of 1600-1630 feet. At locality 11 at 2270-2300 feet poorly preserved specimens occur which are identified as *Pseudophragmina* (*Athecocyclina*) *stephensoni* (Vaughan). Cole (1959, p. 386) considered *Dis-*

cocyclina cookei Vaughan, a species described from the Salt Mountain limestone, to be a synonym of *P.* (*A.*) *stephensoni.* If this is correct, the Salt Mountain limestone equivalent in the Sun Oil Co., Brady Belcher well No. 3, in Walton County would be at approximately 2300 feet.

Pseudophragmina (*Proporocyclina*) *clarki* (Cushman) from locality 11 is a middle Eocene species not previously reported from the Caribbean region or the Gulf Coast of the United States. The evidence indicates that it occurs in the well in Walton County, Florida, in strata of middle Eocene age.

As *Discocyclina* (*Discocyclina*) *waltonensis,* n. sp., occurs with *P.* (*P.*) *tobleri* in the sample at 1752 feet (loc. 10), its stratigraphic position in Florida is uncertain. It could be another marker for the *P.* (*P.*) *tobleri* zone which may be either middle or lower Eocene in age.

Lituonella grandicamerata, n. sp., is associated with species (Table 3, loc. 5) which characterize the Avon Park limestone in Duval County, Florida. The available data suggest that it occurs in the basal part of the Avon Park limestone and is geographically restricted to northeastern Florida.

SYSTEMATIC DESCRIPTIONS

(Genera and species are arranged alphabetically)

Asterocyclina monticellensis Cole and Ponton Pl. 4, figs. 1,2,8,10

1934. *Discocyclina* (*Asterocyclina*) *monticellensis* Cole and Ponton, Amer. Midland Nat., v. 5, No. 2, pp. 141, 142, pl. 2, figs. 6-11.

1952. *Asterocyclina monticellensis* Cole and Ponton, Cole and Gravell, Jour. Paleont., v. 26, No. 5, p. 718, pl. 95, fig. 4; pl. 96, fig. 2; pl. 97, figs. 1-11.

1956. *Asterocyclina monticellensis* Cole and Ponton, Cole, Bull. Amer. Paleont., v. 36, No. 158, p. 214, pl. 29, figs. 4,5.

Occurrence elsewhere.—St. Bartholomew; Jamaica

Remarks.—The type locality of this species is a sample at a depth of 1740 feet in the Southern States Oil Corporation well (W-19) located about one and one-half miles north of Monticello, Jefferson County, Florida. This sample contained in addition to *A. monticellensis* numerous specimens of *Lepidocyclina ariana* Cole and Ponton, *Fabularia matleyi* (Vaughan) (=*F. vaughani*), and *Dictyoconus americanus* (Cushman). The Applins (1944, p. 1695; fig. 28A) considered this sample represented the top of the Lake City limestone in this well.

In the Ravlin-Brown, V. G. Philips, well No. 1 (W-440) near Wakulla, Wakulla County, Florida, Cole (1945, p. 93) found numerous specimens of *A. monticellensis* at 1757-1768 feet associated with *Camagueyia perplexa* Cole and Bermudez, *Discorbis inornatus* Cole, *Febularia matleyi* (Vaughan), and *Lepidocyclina* (*Lepidocyclina*) *ariana* Cole and Ponton. The top of the Lake City limestone is recorded by the Applins (1944, p. 1697; fig. 23) in this well as being at a depth of 1750 feet.

In northeastern Florida in Nassau County in the St. Mary's River Oil Corporation, Hilliard Turpentine Company well No. 1 (W-366) Cole (1944, p. 34) found specimens of *L.* (*Lepidocyclina*) *ariana* Cole and Ponton at a depth of 1065-1070 feet. The first specimens of *A. monticellensis* appeared at a depth of 1198-1200 feet, and specimens of *Lepidocyclina* (*Polylepidina*) *antillea* Cushman were found at a depth of 1245-1250 feet. In this well the top of the Lake City limestone was given by the Applins (1944, p. 1697; fig. 30) as occurring at 945 feet at which depth the first specimens of *Dictyoconus americanus* (Cushman) appeared.

In the California-Coastal well No. 2 drilled off shore in St. George Sound, Franklin County, Florida, *A. monticellensis* was found at a depth of 1880-1890 feet in association with *Lepidocyclina* (*Lepidocyclina*) *pustulosa* H. Douvillé. *L.* (*Polylepidina*) *antillea* occurred first in this well at a depth of 2010-2020 and appeared in other samples to a depth of 2340-2350 feet.

From the data on Florida wells it would appear that *A. monticellensis* occurs at a stratigraphically higher horizon than *L.* (*P.*) *antillea.* However, in St. Bartholomew (Cole, 1958*a*, p. 190; Hanzawa, 1959, pp. 843, 844) and Jamaica (Cole, 1956, Table 4; 1958*a*, p. 191) *A. monticellensis* and *L.* (*P.*) *antillea* occur in the same samples.

Camagueyia perplexa Cole and Bermudez Pl. 4, figs. 5,6

1944. *Camagueyia perplexa* Cole and Bermudez, Bull. Amer. Paleont., v. 28, No. 113, pp. 5. 6, pl. 1, figs. 1,2.
1945. *Camagueyia perplexa Cole and Bermudez,* Cole Florida Geol. Sur., Bull. 28, p. 111, pl. 15, fig. 4.
1945. *Camagueyia perplexa* Cole and Bermudez, Cole Florida Geol. Sur., Bull. Res., Sp. Publ. No. 25, p. 96.

Occurrence elsewhere.—Cuba; Dominican Republic.

Remarks.—An axial (Pl. 4, fig. 6) and a transverse (Pl. 4, fig. 5) section of specimens which conform to the type of *C. perplexa* are illustrated. Figure 4 of Plate 4 is a transverse section of a specimen which is identical to the type of *Discorbis inornatus* Cole. The structure of the outer wall in the specimen of *D. inornatus* is the same as that of *C. perplexa,* and the arrangement of the chambers within the tests is similar.

These two species occur together at locality 2. Specimens of *D. inornatus* are more abundant than those which would be assigned to *C. perplexa.* The association of these two species at this locality, the similarity of the wall structure, and the general configurative of the tests is suggestive that these two species may, in reality, be only forms of a single species in which some individuals develop tests which are axially elongated (*perplexa* type), where others are compressed (*inornatus* type). A number of well-oriented axial sections would be needed to demonstrate whether this postulate is correct.

Camerina willcoxi (Heilprin) Pl. 4, figs. 9, 14-16

1958. *Operculinoides willcoxi* (Heilprin), Cole, Bull. Amer. Paleont., v. 38, No. 173, pp. 273-276, pl. 33, figs. 1, 3-12 (references).

Occurrence elsewhere.—Mexico; Panama; Peru; Curaçao; upper middle to upper Eocene.

Remarks.—Cole (1960*a*, p. 190) classified all camerinids with undivided chambers, formerly placed in several genera, as *Camerina.* The specimens (Pl. 4, figs. 9, 14-16), although small, are all assigned to this species. Figure 15, Plate 4 is probably a microspheric individual, whereas the others are megalospheric.

Coskinolina elongata Cole Pl. 1, fig. 12; Pl. 2, fig. 9; Pl. 3, figs. 4, 8

1942. *Coskinolina elongata* Cole, Florida Geol. Sur., Bull. 20, pp. 20, 21, pl. 3, figs. 15-17; pl. 4, figs. 1-3; pl. 5, figs. 2-7; pl. 16, fig. 6.

1956. *Coskinolina elongata* Cole, Cole, Bull. Amer. Paleont., v. 36, No. 158, p. 215, pl. 24, figs. 6-11; pl. 31, figs. 1,2.

Occurrence elsewhere.—Jamaica.

Remarks.—Several additional illustrations of this species from locality 14, Jamaica, are given for comparison with *Dictyoconus floridanus* (Cole) which was originally assigned to the genus *Coskinolina.* Figure 8, Plate 2 is a section parallel to the dorsal surface of the test of *D. floridanus* which just penetrates the marginal trough. Figure 9, Plate 2 is a comparable section of *C. elongata.* Although the pattern is the same, the wall structure is different.

As Douglass (1960, p. 255) discovered, the wall structure of *D. floridanus* " . . . is not like that of *Coskinolina,* but is typical of the Orbitolinidae." *D. floridanus* was originally placed in the genus *Coskinolina* by Cole (1941, p. 25) because of the simplicity of the subdivisions of the marginal zone.

The structure of the wall of *C. elongata* is similar to that of *Lituonella grandicamerata* and *L. floridana.* However, transverse sections (Pl. 3, figs. 4, 8) of *C. elongata* have the marginal trough subdivided into chamberlets, whereas comparable transverse sections (Pl. 1, fig. 8; Pl. 3, fig. 9) of *L. grandicamerata* and of *L. floridana* (Pl. 1, fig. 6) have an open undivided marginal trough.

Dictyoconus americanus (Cushman) Pl. 2, figs, 3, 6

1956. *Dictyoconus americanus* (Cushman), Cole, Bull. Amer. Paleont., v. 36, No. 158, pp. 217, 218, pl. 25, figs. 8-11.

Occurrence elsewhere.—Widely distributed in the middle Eocene of the Caribbean region.

Remarks.—The transverse section (Pl. 2, fig. 6) was made through the embryonic chambers for comparison with similar sections of *Lituonella grandicamerata* (Pl. 2, figs. 1, 4; Pl. 1, fig. 9). The complex subdivision of the marginal trough in *Dictyoconus americanus* is shown by the transverse section (Pl. 2, fig. 6) and the axial section (Pl. 2, fig. 3).

Dictyoconus floridanus (Cole) Pl. 2, figs. 2, 5, 8

1941. *Coskinolina floridana* Cole, Florida Geol. Sur., Bull. 19, pp. 24, 25, pl. 3, figs. 1-7; pl. 4, figs. 1-9; pl. 5, figs. 1-5, 11; pl. 18, fig. 9.

1960. *Dictyoconus floridanus* Cole, Douglass, Micropaleont., v. 6, No. 3, p. 258, pl. 5, figs. 13-16 (references).

Occurrence elsewhere.—Lower Cretaceous of Florida, Louisiana, Texas, New Mexico, Arizona, Mexico, Venezuela, and Switzerland (as *Coskinolina sunnilandensis* Maync); Eocene of Cuba and Jamaica (as *C. floridana*).

Remarks.—Douglass (1960, p. 258) transferred this species to the genus *Dictyoconus* as "The wall structure of *D. floridanus* is unlike that of *Coskinolina,* however, and is typical of the structure found in other Orbitolinidae."

Discocyclina (Discocyclina) marginata (Cushman) Pl. 10

1952. *Discocyclina* (*Discocyclina*) *marginata* (Cushman), Cole and Gravell, Jour. Paleont., v. 26, No. 5, pp. 714-716, pl. 93, figs. 1-9; pl. 94, figs. 1-8; pl. 95, figs. 7, 8 (references).

1959. *Discocyclina* (*Discocyclina*) *marginata* (Cushman), Cole, Bull. Amer. Paleont., v. 39, No. 182, pp. 381, 382.

Cole and Gravell (1952, p. 714) discussed this species whose type came from the middle Eocene of St. Bartholomew. Although the specimens from locality 12 (Ballard well), Clinch County, Georgia, are smaller than the specimens from St. Bartholomew and Cuba illustrated by Cole and Gravell, they possess the same internal structure.

Occurrence elsewhere.—*D. marginata* occurs in St. Bartholomew in association with *Lepidocyclina antillea* and other species, and in Cuba with *Gunteria floridana* and other species which in Florida have been recorded from the Lake City and Avon Park limestones. *D. marginata* has been recorded elsewhere in Cuba as *D. crassa* and *D. cubensis,* in Barbados as *D. harrisoni,* and in California as *D. californica.*

Remarks.—Although in the older literature there are records of the presence of *Discocyclina* in Florida and Georgia, all of these species belong to other genera of the discocyclinids. Therefore, the discovery of *D. marginata* in Georgia and *D. waltonensis* in Florida is the first authenticated record of the occurrence of *Discocyclina s. s.* in these states.

Caudri (1944, p. 35) was the first to state that *Discocyclina* (*Discocyclina*) probably did not range into the American upper Eocene and presumably had a stratigraphic range from Paleocene through middle Eocene in the Caribbean region. So far no evidence has been found to contradict this assumption.

Discocyclina (Discocyclina) waltonensis Cole and Applin, n. sp.
Pl. 11, figs. 1-3, 7-9

The test is small with a diameter of about 1.0 mm and a thickness at the center of about 0.5 mm. The surface is densely covered by small slightly projecting papillae.

The initial embryonic chamber is spherical with an internal diameter of about 35 μ and is partly embraced by a reniform second embryonic chamber. The internal distance across both chambers is 80 to 90 μ.

The equatorial chambers are square and arranged so that the radial chamber walls in adjacent annuli alternate in position.

The openings of the lateral chambers are slitlike and not arranged in regular tiers. The roofs and floors of the lateral chambers are thick. There are between five and eight layers of lateral chambers on each side of the equatorial layer at the center of test. Small pillars are present (Pl. 11, fig. 3), and an occasional specimen (Pl. 11, fig. 1) has a relatively thick pillar in the central area.

Occurrence.—Locality 10 at 1752 feet in association with specimens identified as *Pseudophragmina* (*Proporocyclina*) *tobleri* Vaughan and Cole.

Remarks.—The equatorial sections of this new species most nearly resemble those of *D.* (*D.*) *barkeri* Vaughan and Cole (see: Cole and

Bermudez, 1947, pl. 5, figs. 9, 10). The vertical sections are similar to those of *D.* (*D.*) *crassa* (Cushman) (see: Vaughan, 1945, pl. 24, fig. 1), a species which Cole and Gravell, 1952, p. 714) placed in the synonymy of *D.* (*D.*) *marginata.*

Fabularia matleyi (Vaughan) Pl. 4, figs. 3, 7, 11-13, 17

1929. *Borelis matleyi* Vaughan, Jour. Paleont., v. 3, pp. 377, 378, pl. 40, figs. 2, 3, 3*a*.
1929. *Borelis jamaicensis* Vaughan, *idem,* pp. 378, 380, pl. 40, figs. 4-10.
1929. *Borelis jamaicensis truncata* Vaughan, *idem,* pp. 380, pl. 40, figs. 11, 12.
1934. *Fabularia vaughani* Cole and Ponton, Amer. Midland Nat., v. 15, pp. 139-141, pl. 1, figs. 1-9.
1937. *Fabularia vaughani* Cole and Ponton, Hanzawa, Jour. Paleont., v. 11, pp. 111-113, pl. 20, figs. 1-4.
1945. *Fabularia vaughani* Cole and Ponton, Cole, Florida Geol. Sur., Bull. 28, pp. 98-101, pl. 15, fig. 6; pl. 16, figs. 1-10.
1945. *Fabularia gunteri* Applin and Jordan, Jour. Paleont., v. 19, pp. 137, 138, pl. 18, figs. 12*a*, *b*.
1956. *Fabularia matleyi* Vaughan, Cole, Bull. Amer. Paleont. v. 36, No. 158, pp. 218, pl. 26, figs. 7-14.

Occurrence elsewhere.—Jamaica

Remarks.—Cole (1956, p. 218) restudied specimens from Jamaica which Vaughan (1929) had placed in the genus *Borelis* and concluded that they should be referred to the genus *Fabularia.* At the same time Cole decided that specimens from Florida which had been named *Fabularia vaughani* represented the same species as the one Vaughan had described under the name "*Borelis*" *matleyi.*

During this study several sections were prepared from topotype specimens (Pl. 4, figs. 3, 7, 11-13, 17) of *Fabularia gunteri.* These specimens are unusually well preserved, and the species *F. gunteri* was based mainly on superficial differences in ornamentation between these specimens and specimens which had been referred to *F. vaughani.* However, the internal structure of *F. gunteri* is the same as that of *F. vaughani* and *F. matleyi.* Therefore, *F. gunteri* is another synonym of *F. matleyi.*

In Florida the stratigraphic range of *F. matleyi* is from the Lake City limestone into the Avon Park limestone.

Lepidocyclina (Polylepidina) antillea Cushman Pl. 5, fig. 2; Pl. 6, fig. 3; Pl. 7, figs. 2, 4-6; Pl. 9, figs. 5, 6.

1960. *Lepidocyclina* (*Polylepidina*) *antillea* Cushman, Cole, Contrib. Cushman Found. Foram. Res., v. 11, Pt. 2, pp. 60, 61, pl. 12, figs. 1-8; pl. 13, figs. 1, 2, 4, 5 (references).
1963. *Lepidocyclina* (*Polylepidina*) *antillea* Cushman, Cole, Bull. Amer. Paleont., v. 46, No. 205, pp. 20, 36, pl. 5, fig. 5; pl. 7, figs. 5, 6.

Occurrence elsewhere.—St. Bartholomew; Jamaica; Mexico.

Remarks.—Five specimens (Pl. 5, fig. 2; Pl. 7, figs. 2, 5; Pl. 9, figs. 5, 6) are illustrated from the Florida wells. Three specimens (Pl. 6, fig. 3; Pl. 7, figs. 4, 6) are from Jamaica (loc. 15). Cole (1958*a*, p. 191) recorded some of the species which occur at this locality in Jamaica. A revised list from this locality (15) follows:

Asterocyclina monticellensis Cole and Ponton
Camerina floridensis (Heilprin)
  striatoreticulata (L. Rutten)
Dictyoconus walnutensis (Carsey)
Fabiania cassis (Oppenheim)
Helicolepidina spiralis Tobler
Lepidocyclina (*Polylepidina*) *antillea* Cushman
Pseudophragmina (*Proporocyclina*) *flintensis* (Cushman)
  perkinsi (Vaughan)

The specimens from Jamaica identified here as *Lepidocyclina* (*Polylepidina*) *antillea* Cushman were classified originally (Cole, 1958*a*, p. 191) as *Eulinderina semiradiata* Baker and Grimsdale as an occasional specimen had one or more periembryonic chambers with an amphistegine kind of aperture. However, this kind of aperture occurs in specimens of *L.* (*P.*) *antillea* from many geographic localities (Cole, 1963, p. 20).

The specimen (Pl. 9, fig. 5) has two sets of embryonic chambers. Although this development has been found in several species of *Lepidocyclina,* this is the first specimen of the subgenus *Polylepidina* in which "twinned" embryonic chambers have been found.

The specimen (Pl. 9, fig. 6) shows the well-developed partial coil of large periembryonic chambers which is one of the outstanding structures in the subgenus *Polylepidina.*

Lepidocyclina (Lepidocyclina) ariana Cole and Ponton Pl. 5, figs. 4, 7, 10-12

1945. *Lepidocyclina* (*Pliolepidina*) *ariana* Cole and Ponton, Cole, Florida Geol. Sur., Bull. 28, pp. 111-115, pl. 15, figs. 1-3; pl. 17, figs. 1-6; pl. 22, figs. 9-14 (references).

1963. *Lepidocyclina* (*Lepidocyclina*) *ariana* Cole and Ponton, Cole, Bull. Amer. Paleont., v. 46, No. 205, p. 20, pl. 1, fig. 4.

Occurrence elsewhere.—Mississippi (as *L. claiborensis* Gravell and Hanna) in the "Cook Mountain, Claiborne Eocene, about 55 feet above the *Lepidocyclina* (*Polylepidina*) *gardnerae* Cole zone" (Gravell and Hanna, 1940, p. 416).

Remarks.—Cole (1944, p. 61, 62) demonstrated that *L. claibornensis* is a synonym of *L. ariana.* Figure 10, Plate 5 represents a specimen with lateral chambers with thin floors and roofs and open cavities (type *L. ariana*), whereas figures 7, 11 represent specimens with lateral chambers with thick floors and roofs and low openings (type *L. claibornensis*).

Lepidocyclina (Lepidocyclina) pustulosa H. Douvillé
Pl. 5, figs. 1, 3, 5, 6, 8, 9;
Pl. 6, figs. 1, 2, 4-8; Pl. 7, figs. 1-3

1963. *Lepidocyclina pustulosa* H. Douvillé, Cole, Bull. Amer. Paleont., v. 46, No. 205, pp. 21-35, pl. 1, fig. 5; pls. 2-4; pl. 5, figs. 1-4; pl. 10, figs. 1-4 (references).

Occurrence elsewhere.—This species is widely distributed in the upper middle and upper Eocene of the Caribbean region.

Remarks.—Cole (1963, pp. 32-35) placed the following species in the synonomy of *L. pustulosa*: *L. cedarkeysensis* Cole, *L. peruviana* Cushman, and *L. r. douvillei* Lisson. All of these species had been identified as occurring in the middle Eocene of Florida. In addition, Cole (1963, p. 33) considered that *Triplalepidina veracruziana* Vaughan and Cole was another synonym of *L. pustulosa.*

A number of illustrations of specimens of *Lepidocyclina,* all of which we consider to be *L. pustulosa,* from various well samples used in this study are given to demonstrate variation between specimens of this species. All the equatorial sections are identical. Superficial differences appear mainly in the vertical sections, but even in such sections the essential internal structures are the same.

As Cole (1963, p. 32-35) has discussed in detail the reasons for the consolidation of these formerly recognized species under one specific name, additional proof is not needed.

Lituonella grandicamerata Cole and Applin, n. sp. Pl. 1, figs. 3, 8, 9, 11;
Pl. 2, figs. 1, 4, 7; Pl. 3, figs. 1-3, 5-7, 9

The test is relatively small with diameters from 1.0 to 4.0 mm., and heights from 0.75 to 2.0 mm. The dorsal surface may be gently convex (Pl. 1, fig. 3) or strongly convex (Pl. 1, fig. 11). The ventral (apertural) surface is always moderately convex. In some specimens (Pl. 3, fig. 6) the convexity of the dorsal and ventral surfaces are about equal. In plan view (transverse) the test is circular.

The dorsal surface of the test shows a series of concentric circles of lighter colored shell material which mark the juncture of the floors and roofs of the marginal trough with the outer wall of the test. At the dorsal apex of the test most specimens have two distinct, round, slightly inflated areas which reflect the underlying bilccular embryonic chambers. The ventral surface is covered by a sequence of small round apertures which are arranged in concentric circles.

Transverse sections (Pl. 1, fig. 9) through the dorsal apex of the test expose the bilocular embryonic chambers. The initial chamber is relatively large and nearly spherical. The second chamber is slightly smaller and reniform in shape. These chambers are surrounded by chambers of the kind which form the marginal trough so arranged that they form a rude incomplete spiral around the embryonic chambers (Pl. 1, fig. 9). Beyond this rude initial spiral the floors and roofs of the marginal trough appear as concentric circles.

Transverse sections (Pl. 2, fig. 4) whose plane is slightly lower than the one just described may encounter in the zone immediately beyond the embryonic chambers the stolons through the roofs and floors of the central shield. This zone is followed by the open marginal troughs arranged in concentric circles.

Transverse sections (Pl. 2, fig. 1) whose plane, although still retaining the embryonic chambers, is cut sufficiently into the body of the test to expose the floors and roofs of the central shield and associated structures so that such a section resembles transverse sections made below the embryonic chambers.

The measurements of the embryonic chambers of these three transverse sections are given in Table 5.

Table 5—Measurement of embryonic chambers of *Lituonella grandicamerata* in transverse section

Specimen		Pl. 2 fig. 1	 fig. 4	Pl 1 fig. 9
Diameters of initial chamber	μ	340 x 500	400 x 450	510 x 510
Diameters of second chamber	μ	350 x 500	160 x 490	200 x 550
Distance across both chambers	μ	750	600	730
Thickness of wall	μ	30	20	40

Transverse sections (Pl. 3, fig. 7), whose plane is just below the embryonic chambers, demonstrate the spiral arrangement of the chambers adjacent to the embryonic chambers.

The transverse sections (Pl. 1, fig. 8; Pl. 2, fig. 7) are ones whose plane is below the embryonic chambers. The section (Pl. 1, fig. 8) was made from a specimen which had a steeply convex dorsal surface so that the greater part of the section shows the open circular chambers of the marginal trough. The other section (Pl. 2, fig. 7) was made from a less convex specimen and shows mainly the structure of the central shield. The section (Pl. 3, fig. 5) resembles the section (Pl. 2, fig. 7) just described. The section (Pl. 3, fig. 9) is an intermediate one which exposes the central shield as well as the marginal trough. In this section (Pl. 3, fig. 9) the development of the sequence of joined, semicircular pores from the floor of the marginal trough (on the left hand side) suggest the manner in which the openings through the floors of the central shield develop.

The internal structure of the test in axial section is illustrated by figures 3, 11, Plate 1; figures 1-3, 6, Plate 3. It should be emphasized that in transverse section and in broken specimens the chambers of the marginal trough are not subdivided and internally are open completely around the test. Measurement of the axial sections are given in Table 6.

Table 6—Measurements of axial sections of *Lituonella grandicamerata*

	Pl. 1		Pl. 3			
Specimen	fig. 3	fig. 11	fig. 1	fig. 2	fig. 3	fig. 6
Diameter mm.	2.4	1.95	2.9	1.15	1.67	3.7
Height mm.	1.4	1.25	1.55	0.75	0.93	1.9
Embryonic chambers:						
Diameters of initial chamber μ	370 x 470	350 x 410	260 x 420	——	——	260 x 230
Diameters of second chamber μ	200 x 320	150 x 320	170 x 200	——	——	90 x 110
Distance across both chambers μ	580	500	470	270	270	380
Marginal trough:						
Width μ	150-400	150-350	90-290	120	90-140	130-320
Height μ	60-70	50-70	50-70	70-80	40-100	70-90
Thickness of floors μ	20	20-40	20-40	20	20	20-40

Comparison with Lituonella roberti Schlumberger.—Specimens of *L. roberti* Schlumberger and H. Douvillé, collected in France by H. T. and A. R. Loeblich, Jr. and deposited in the U. S. National Museum, have been made available by R. C. Douglass and K. N. Sachs. Sections cut from these specimens are illustrated (Pl. 1, figs. 4, 5, 10; Pl. 3, fig. 10).

These illustrations of *L. roberti* may be supplemented by the ones given recently by Poignant (1960, pl. 1, figs. 1-6; pl. 2, figs. 1-7). He considered that the specimens illustrated by his figures 1-7, plate 2 were a new species which he named *L. cuvillieri.* However, we consider that they are well within the specific limits of *L. roberti.*

The transverse section (Pl. 1, fig. 4) through the embryonic chambers of *L. roberti* shows a distinct partial coil around the embryonic chambers similar to the one in *L. grandicamerata.* The transverse section (Pl. 1, fig. 10) is not entirely satisfactory but does have the same general construction as does comparable sections of *L. grandicamerata.* The arrangement of the internal structures (Pl. 1, fig. 5; Pl. 3, fig. 10) of *L. roberti* are similar to those of *L. grandicamerata,* but in *L. grandicamerata* these structures are less coarse.

Comparison with American species of Lituonella.—Three sections (Pl. 1, figs. 1, 6, 7) of *L. floridana* are illustrated. The composition of the test is the same as that of *L. grandicamerata,* and the arrangement of the internal structures is similar. However, the central shield is extremely small so that the marginal trough occupies the major part of the test internally.

Pseudochrysalidina floridana Cole Pl. 1, fig. 2

1941. *Pseudochrysalidina floridana* Cole, Florida Geol. Sur., Bull. 19, p. 36, pl. 1, figs. 10, 11; pl. 2, fig. 4.

1956. *Pseudochrysalidina floridana* Cole, Cole, Bull. Amer. Paleont., v. 36, No. 158, p. 215, pl. 24, figs. 1, 2; pl. 25, figs. 1-5.

Occurrence elsewhere.—Jamaica.

Remarks.—The composition of the wall of this species is similar to that of *Lituonella.*

Pseudophragmina (Proporocyclina) clarki (Cushman) Pl. 9, figs. 1-4

1958. *Pseudophagmina* (*Proporocyclina*) *clarki* (Cushman), Cole, Bull. Amer. Paleont., v. 38, No. 176, pp. 419, 420, pl. 52, figs. 3-11 (references).

Occurrence elsewhere.—California; Oregon; Washington; Peru.

Remarks.—The embryonic chambers of this species are large and the equatorial chambers are Type II (Cole, 1958*c*, 413). The illustrations (Pl. 9, figs. 1-4) should be compared with the ones given by Vaughan (1945, pl. 39, figs. 1-4) of *P.* (*P.*) *peruviana,* a species which Cole (1958, p. 419) considered to be a synonym of *P.* (*P.*) *clarki,* and with the specimens of *P.* (*P.*) *clarki* illustrated by Cole (1958*c*; pl. 52, figs. 3-11).

The sections which are illustrated have been compared with specimens from California and Peru, and no significant difference could be observed.

It should be noted that this species was found at 1000-1030 feet in the Brady Belcher well (loc. 11) and at 1300-1330 feet in this same well. The specimens from the sample at 1300-1330 feet are suspected of being "cavings" from the thousand foot level.

Pseudophragmina (Proporocyclina) teres Cole and Gravell Pl. 8

1952. *Pseudophragmina* (*Proporocyclina*) *teres* Cole and Gravell, Jour. Paleont., v. 26, No. 5, pp. 725, 726, pl. 100, figs. 3, 10-12, 14; pl. 101, figs. 6-8.

This species is characterized by possessing Type I equatorial chambers (Cole, 1958*c*, p. 413), and slitlike, irregularly arranged, lateral chambers whose roofs and floors are thick and flat.

Occurrence elsewhere.—This species was described from Peñon Seep, Matanzas Province, Cuba, where it was associated with numerous other species (Table 4). Later, it was found in St. Bartholomew in association with *Lepidocyclina antillea* among other species (Table 4).

Pseudophragmina (Proporocyclina) tobleri Vaughan and Cole
Pl. 11, figs. 4-6, 10-12

1941. *Pseudophragmina* (*Proporocyclina*) *tobleri* Vaughan and Cole, Geol. Soc. Amer., Sp. Pap. 30, p. 62, pl. 21, fig. 6; pl. 22, figs. 3, 4.
1945. *Pseudophragmina* (*Proporocyclina*) *tobleri* Vaughan and Cole, Vaughan, Geol. Soc. Amer., Mem. 9, p. 94, pl. 37, figs. 4, 5.
1959. *Pseudophragmina* (*Proporocyclina*) *tobleri* Vaughan and Cole, Cole, Bull. Amer. Paleont., v. 39, No. 182, pp. 385, 386, pl. 32, figs. 5-12.

Although several equatorial sections were made, they did not photograph satisfactorily. However, one of equatorial sections is illustrated as figure 10, Plate 11. Detailed study of the equatorial sections proved that the equatorial chambers are Type II (Cole, 1958*c*, p. 413).

The vertical sections (Pl. 11, figs. 4-6, 11, 12) were compared with topotype specimens (Cole, 1959, pl. 32, figs. 5, 6, 8) and are identical.

Occurrence elsewhere.—This species is known from its type locality on Soldado Rock, Trinidad, and one other locality also on Soldado Rock.

Remarks.—Although Vaughan and Cole (1941, p. 27) considered that *P. tobleri* occurred in Trinidad " . . . at a horizon above the typical 'Jacksonian' of Kugler section," Caudri (1944, p. 35) postulated that this species came from " . . . a high-Paleocene (or perhaps lower or middle?) Eocene marl . . . " Recently, Cole (1959, p. 381) stated " . . . the *P. tobleri* zone may be assigned provisionally to the middle Eocene" as he found *Discocyclina* (*Discocyclina*) *anconensis* Barker, a supposedly middle Eocene species, in a sample from Soldado Rock in association with *P. tobleri*.

The Applins (1944, p. 1742, fig. 5) assigned the sample at 1752 feet in the Oil City Corporation Walton Land Timber Company well No. 1, Walton County, Florida, which contained *P. tobleri* to "Beds of Wilcox age" (lower Eocene). In this same well they recorded the top of the lower Eocene as occurring at approximately 1508 feet and the top of the Paleocene at approximately 2010 feet.

The other sample which contained *P. tobleri* came from a depth of 1600-1630 feet from the Sun Oil Company Brady Belcher well No. 3 which was drilled also in Walton County, Florida. In this well at a depth of 2270-2300 feet there were specimens which were identified as *Pseudophragmina* (*Athecocyclina*) *stephensoni* (Vaughan), a species which Cole (1959, p. 380) suggested " . . . is a high Paleocene species."

From the data available it would appear in Florida that *P. tobleri* marks a zone within the lower Eocene although there is the possibility that these strata may be lower middle Eocene.

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PLATES

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	6. Transverse section, X 40, near the apertural end.	
2.	**Pseudochrysalidina floridana** Cole	28
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3, 8, 9, 11.	**Lituonella grandicamerata** Cole and Applin, n. sp.	25
	3,11. Axial sections; 3, type, X 20; 11, X 40.	
	8. Transverse section, X 40, just below embryonic chambers.	
	9. Transverse section, X 20, through embryonic chambers.	
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4, 5, 10.	**Lituonella roberti** Schlumberger	28
	4. Transverse section, X 20, through embryonic chambers.	
	5. Axial section, X 20.	
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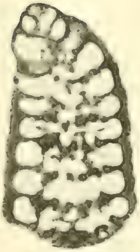
	Axial section, X 20.	

1-3, 6-9, 11. Loc. 5 at a depth of 825-835 feet.
4,5, 10. Loc. 16.
12. Loc. 14 .



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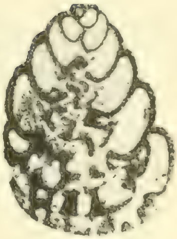

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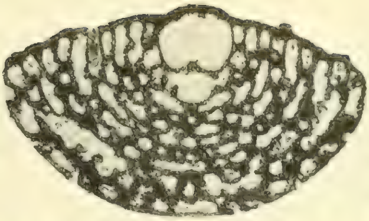

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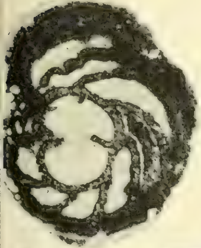

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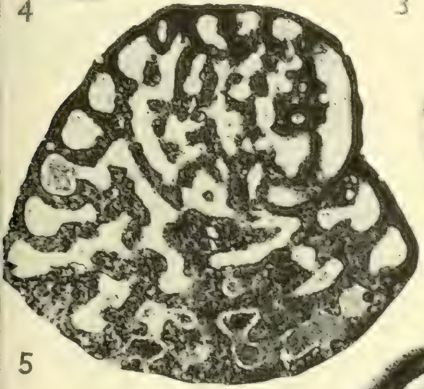

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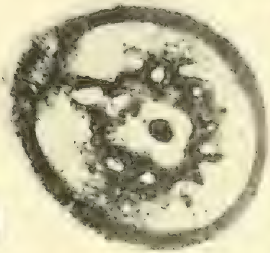

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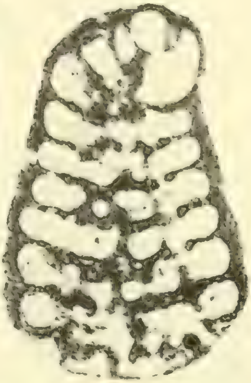

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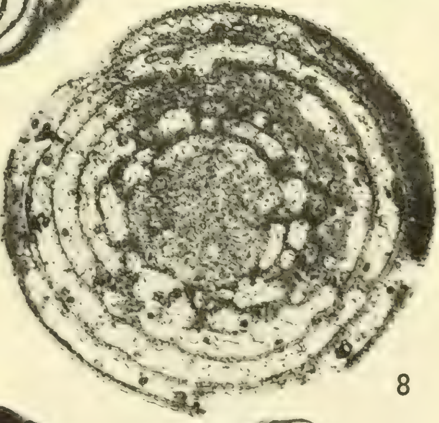

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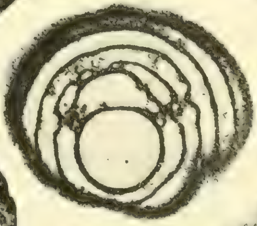

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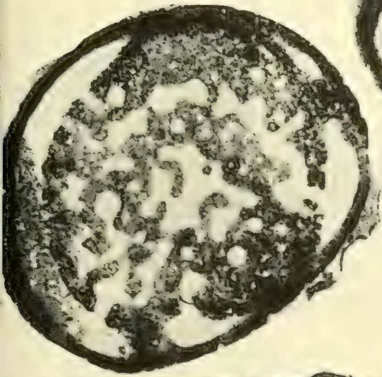

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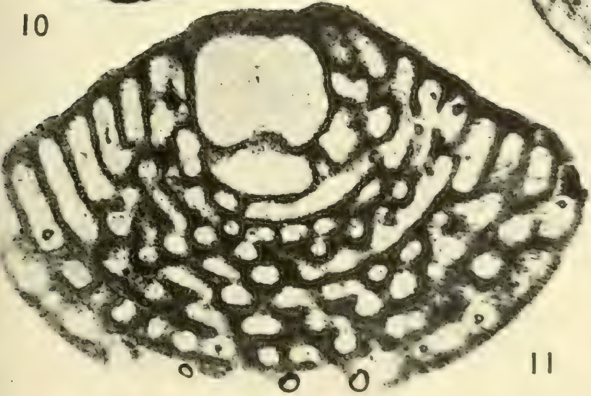

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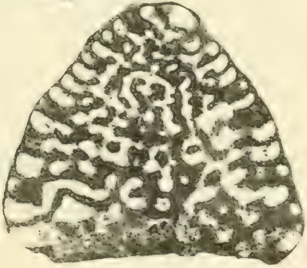

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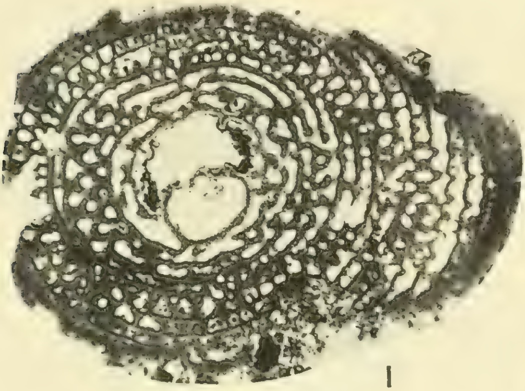
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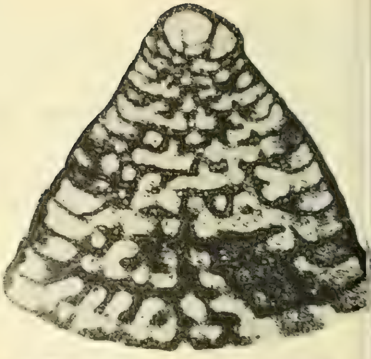
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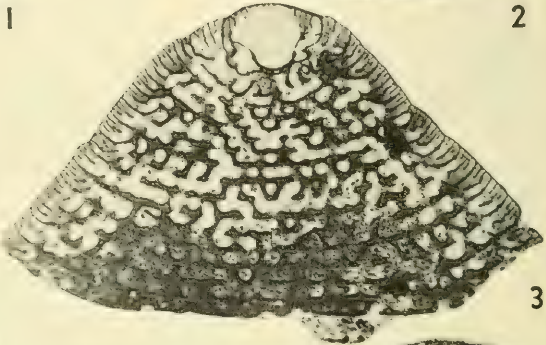
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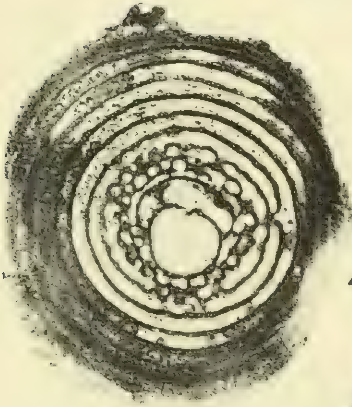
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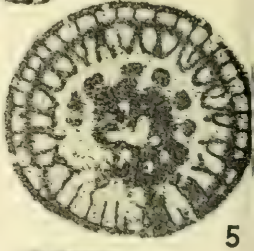
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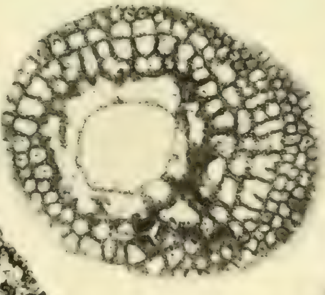
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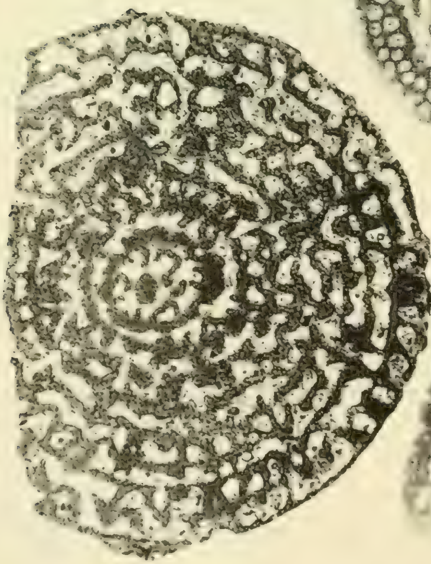
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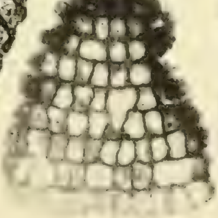
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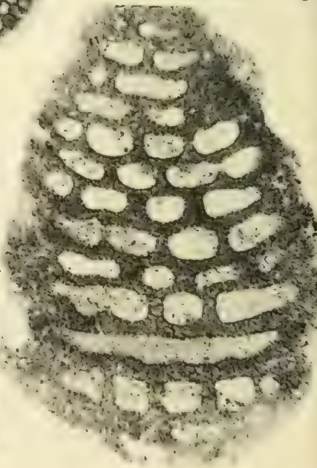
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EXPLANATION OF PLATE 2

Figure   Page

1, 4, 7. **Lituonella grandicamerata** Cole and Applin, n. sp. 25

1,4. Transverse sections, X 20, through embryonic chambers.
7. Transverse section, X 20, just below embryonic chambers.

2, 5, 8. **Dictyoconus floridanus** (Cole) 21

2. Axial section, X 40.
5. Transverse section, X 40.
8. Section, X 40, to illustrate the internal structure of the marginal troughs just below the exterior wall of the test.

3, 6. **Dictyoconus americanus** (Cushman) 21

3. Axial section, X 20.
6. Transverse section, X40, through the embryonic chambers.

9. **Coskinolina elongata** Cole 20

Section, X 40, to illustrate the internal structure of the marginal troughs just below the exterior wall of the test.

1. Loc. 9 at a depth of 640 feet.
2,4,5,7,8. Loc. 5 at a depth of 825-835 feet.
3. Loc. 8 at a depth of 2070-2080 feet.
6. Loc. 7 at a depth of 2000 feet.
9. Loc. 14.

EXPLANATION OF PLATE 3

Figure Page

1-3, 5-7, 9. **Lituonella grandicamerata** Cole and Applin, n. sp. 25

1-3,6. Axial sections; 1,6, X 20; 2,3, X 40.

5. Transverse section, X 20, just below embryonic chambers.

7. Transverse section, X 20, below embryonic chambers, but within the initial zone of coiled chambers.

9. Transverse section, X 20, near the apertural end.

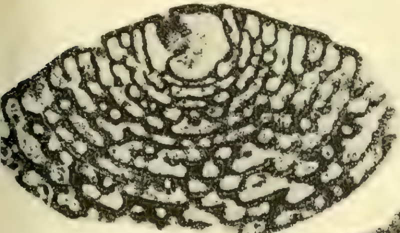
4, 8. **Coskinolina elongata** Cole 20

4,8. Transverse sections, X 20, near the apertural end.

10. **Lituonella roberti** Schlumberger 28

Axial section, X 20.

1,5,6,9. Loc. 5 at a depth of 825-835 feet.
2. Loc. 9 at a depth of 610 feet.
3,7. Loc. 1 at a depth of 610-628 feet.
4,8. Loc. 14.
10. Loc. 16.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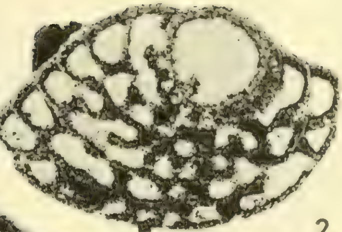
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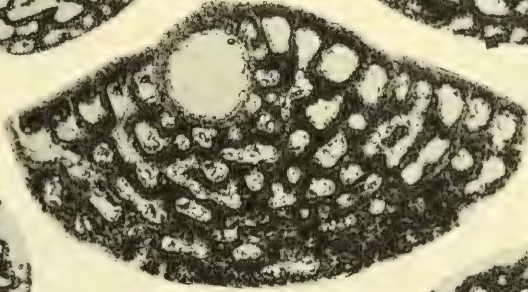
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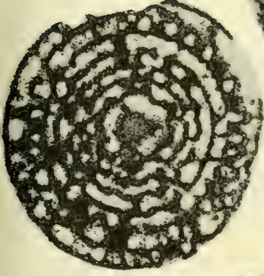
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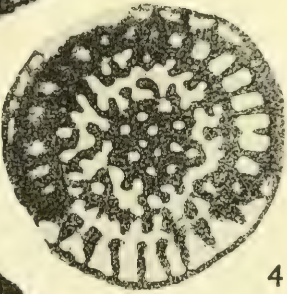
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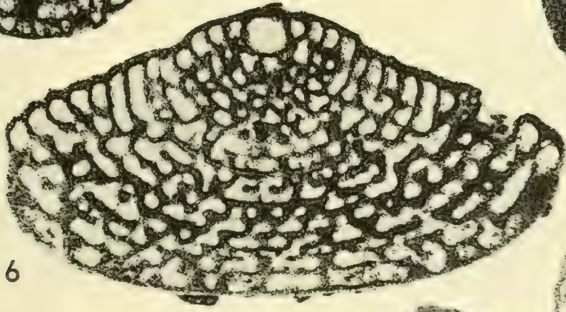
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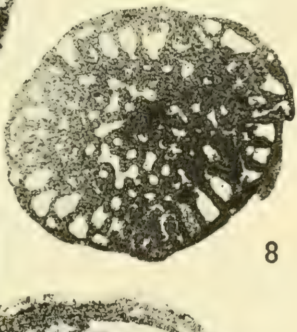
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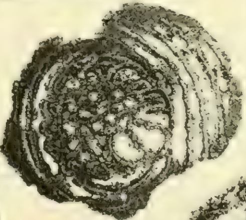
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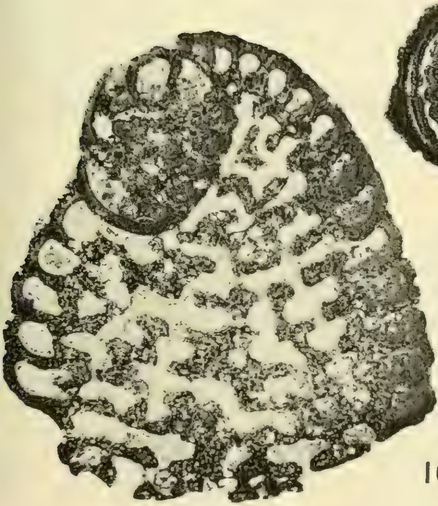
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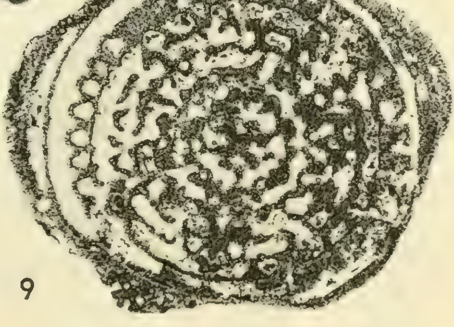
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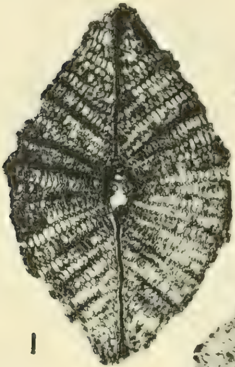
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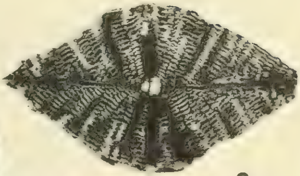
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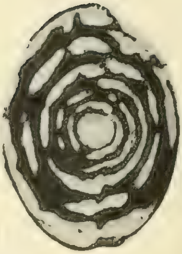
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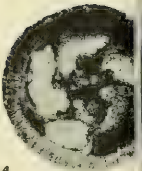
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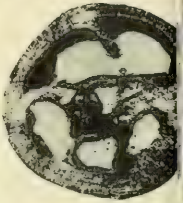
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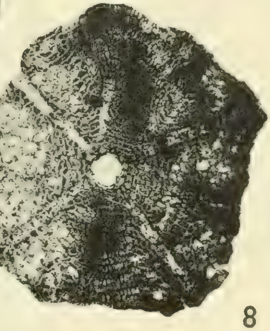
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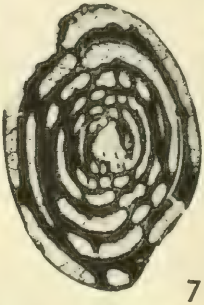
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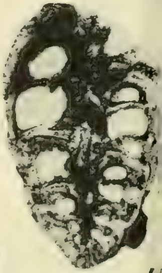
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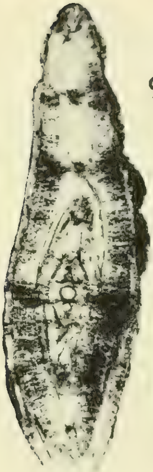
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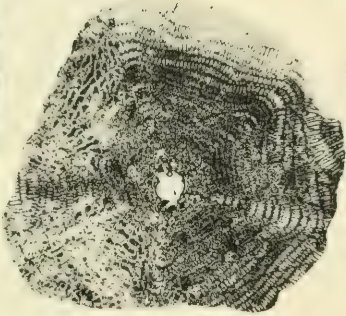
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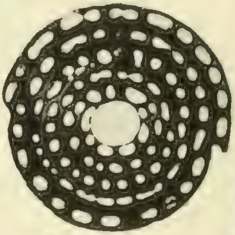
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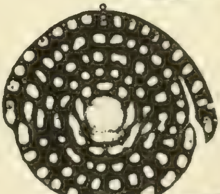
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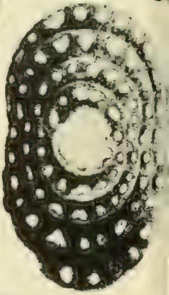
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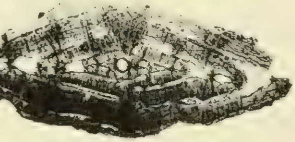
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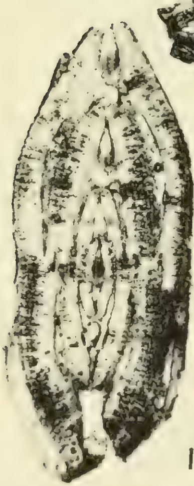
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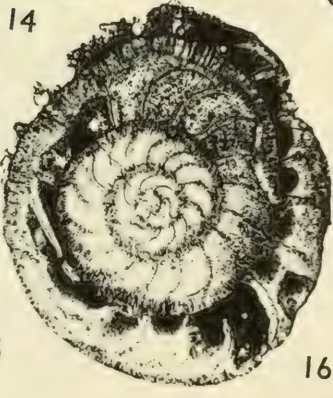
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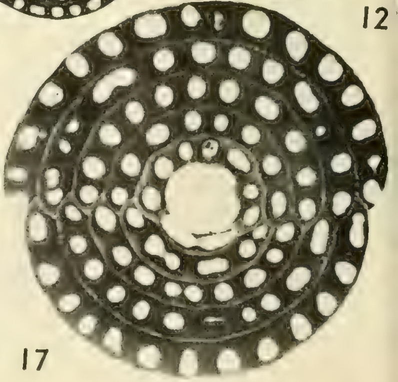
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EXPLANATION OF PLATE 4

Figure	Page

1, 2, 8, 10. **Asterocyclina monticellensis** Cole and Ponton.................. 18

1,2. Vertical sections, X 20.

8,10. Equatorial sections, X 20.

4. **Discorbis inornatus** Cole.. 19

4. Transverse section, X 40, of a typical specimen of this species.

5, 6. **Camagueyia perplexa** Cole and Bermudez.......................... 19

5. Transverse section, X 40, of a specimen similar to the one illustrated as figure 6.

6. Axial section, X 40, of a specimen similar to the type of *Camagueyia perplexa.*

3, 7, 11-13, 17. **Fabularia matleyi** (Vaughan).. 23

3,7. Axial sections, X 20, of topotypes of *Fabularia gunteri* Applin and Jordan.

11,13,17. Transverse sections of topotypes of *Fabularia gunteri* Applin and Jordan; 11,13,X 20; 17, X 40.

12. Transverse section, X 40, of the kind of specimen formerly identified as *Fabularia vaughani* Cole and Ponton.

9, 14-16. **Camerina willcoxi** (Heilprin).. 20

9,14,15. Transverse sections; 9, 15, X 40; 14, X 20; 9,14, megalospheric specimens; 15, microspheric specimen.

16. Median section, X 20, of a megalospheric specimen.

1,2,8-10,14-16. Loc. 6; 1 at a depth of 2010-2020 feet; 2,8,10 at 1880-1890 feet; 9,15 at 1580-1590 feet; 14,16 at 2100-2120 feet.

3,7,11,13,17. Loc. 1 at a depth of 515-520 feet.

4-6,12. Loc. 2 at a depth of 895-905 feet.

EXPLANATION OF PLATE 5

Figure Page

1, 3, 5, 6, 8, 9. **Lepidocyclina (Lepidocyclina) pustulosa** H. Douvillé........ 25

1. Equatorial section, X 20.

3,8. Vertical sections, X 40, of specimens similar to those illustrated as *Lepidocyclina cedarkeysensis* Cole; compare with figures 1-6, plate 12, Florida Geol. Sur., Bull. 20, 1942.

5. Vertical section, X 40, of a specimen with a double layer of equatorial chambers in the peripheral zone (top of specimen) similar to specimens formerly identified as *Triplalepidina veracruziana* Vaughan and Cole; compare with figure 3, plate 14, Bull. Amer. Paleont., vol. 46, No. 205, 1963.

8,9. Vertical sections, X 40, of specimens similar to those illustrated as *Lepidocyclina peruviana* Cushman (see: figures 1-7, plate 15, Florida Geol. Sur., Bull. 26, 1944).

2. **Lepidocyclina (Polylepidina) antillea** Cushman................ 23

Vertical section, X 20, to illustrate the rapid increase in height of the equatorial chambers.

4, 7, 10-12. **Lepidocyclina (Lepidocyclina) ariana** Cole and Ponton.. 24

4,7,11. Vertical sections, X 20, of specimens previously called *Lepidocyclina claibornensis* Gravell and Hanna (see: figures 17, 18, plate 57, Jour. Paleont., v. 14, No. 5, 1940).

10. Vertical section, X 40, of a specimen similar to the type.

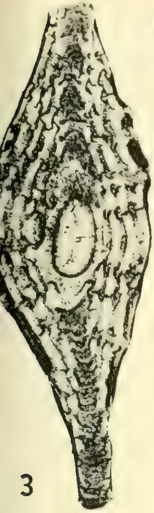
12. Equatorial section, X 40.

1,2,4,5,7,9,10,12. Loc. 6; 1,5,7, at a depth of 1260-1270 feet; 2, at 2340-2350 feet; 4, 10,12, at 1580-1590 feet; 9, at 1880-1890 feet.

3,6,8. Loc. 3 at a depth of 1165-1180 feet.

11. Loc. 12 at a depth of 820-840 feet.

PLATE 5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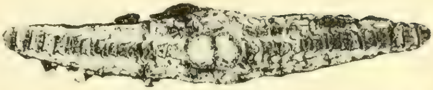
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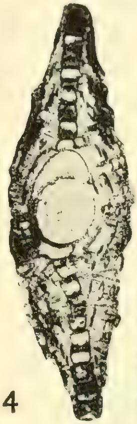
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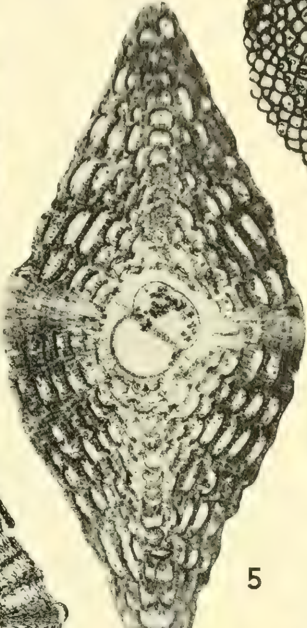
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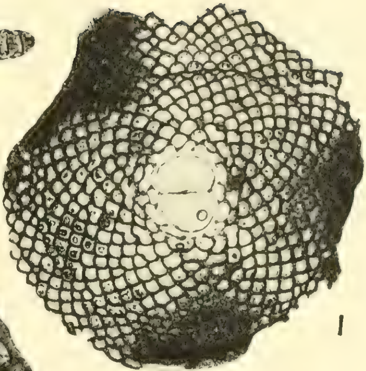
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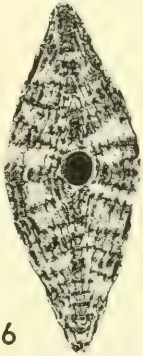
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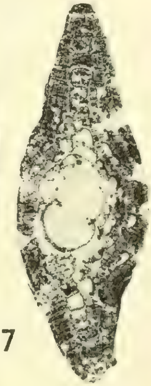
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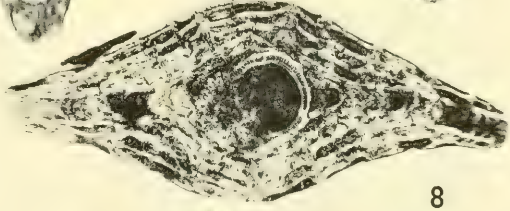
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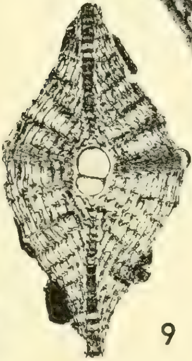
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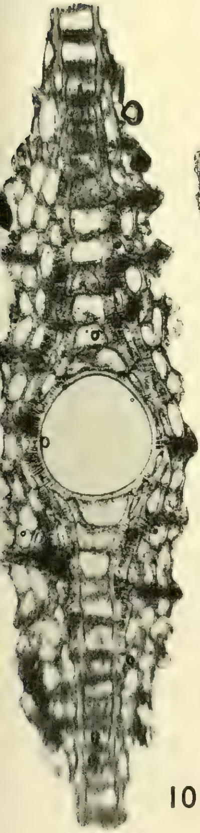
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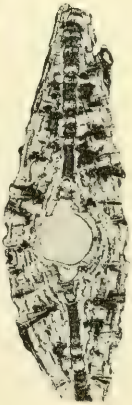
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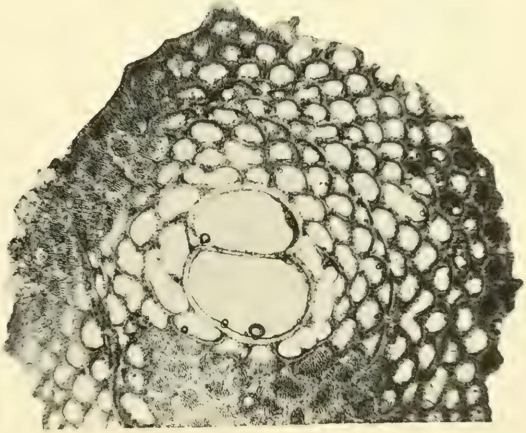
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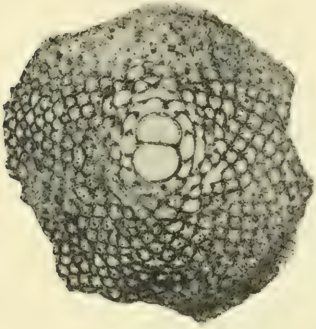
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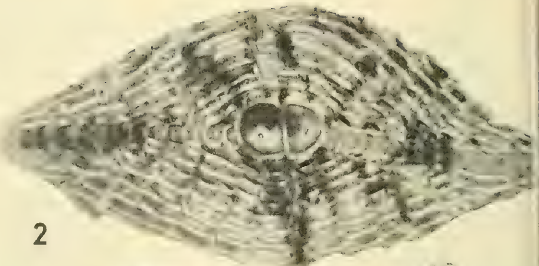
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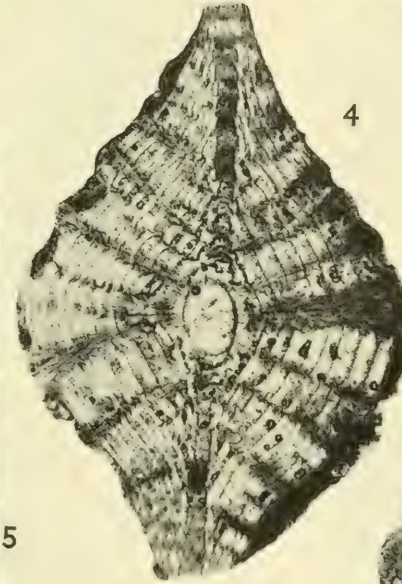
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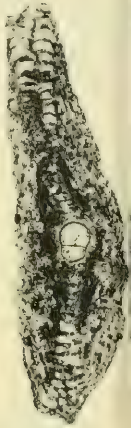
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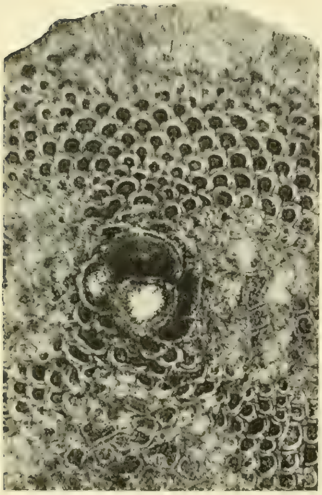
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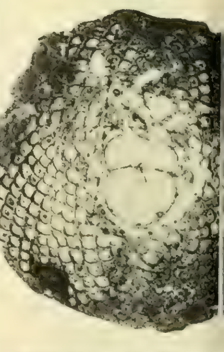
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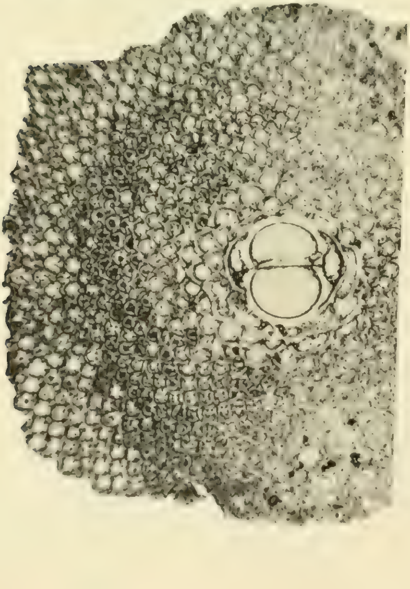
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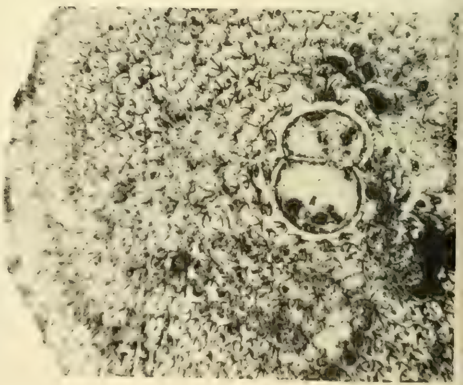
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Explanation of Plate 6

Figure		Page
1, 2, 4-8.	**Lepidocyclina (Lepidocyclina) pustulosa** H. Douvillé	25
	1,5,6-8. Equatorial sections; 1,7,X 20; 5,6,8,X 40.	
	2,4. Vertical sections, X 40.	
3.	**Lepidocyclina (Polylepidina) antillea** Cushman	23
	Vertical section, X 20, of a specimen in which the equatorial layer has a double row of chamberlets in the peripheral zone.	

1,2. Loc. 12; 1, at a depth of 820-840 feet; 2, at 1090-1140 feet.

3. Loc. 15.

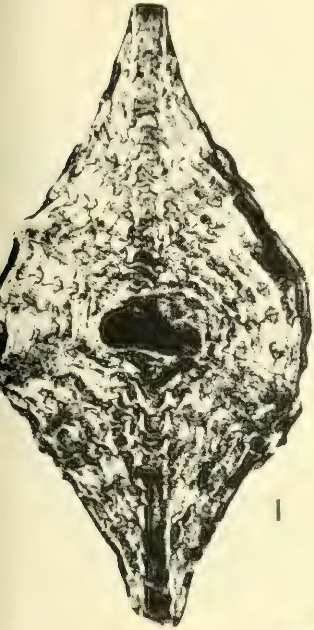
4,6,7. Loc. 6; 4, 6, at a depth of 1880-1890 feet; 7, at a depth of 1260-1270 feet.

5,8. Loc. 3 at a depth of 1165-1180 feet.

EXPLANATION OF PLATE 7

Figure		Page
1, 3.	**Lepidocyclina (Lepidocyclina) pustulosa** H. Douvillé Vertical sections, X 40.	25
2, 4-6.	**Lepidocyclina (Polylepidina) antillea** Cushman 2,4. Vertical sections, X 40. 5,6. Equatorial sections, X 40.	23

1,2. Loc. 3 at a depth of 1165-1180 feet
3. Loc. 12 at a depth of 1090-1140 feet.
4,6. Loc. 15.
5. Loc. 6 at a depth of 2340-2350 feet.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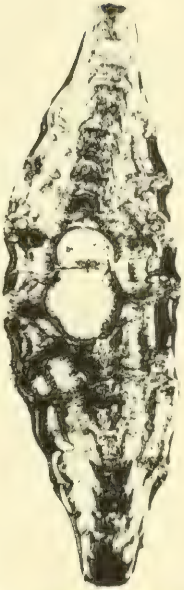
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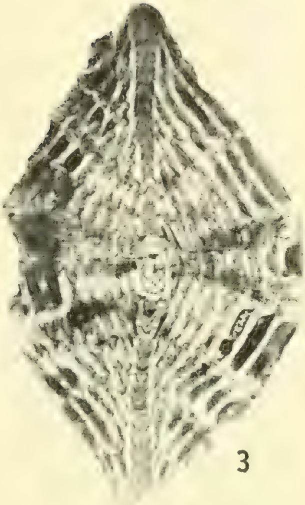
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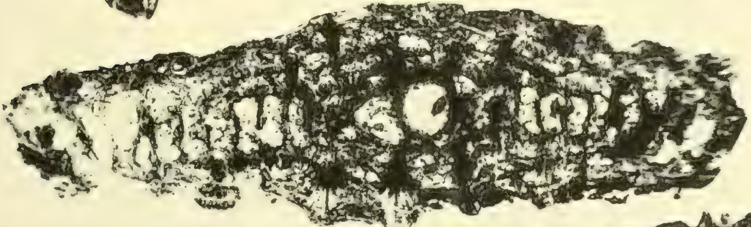
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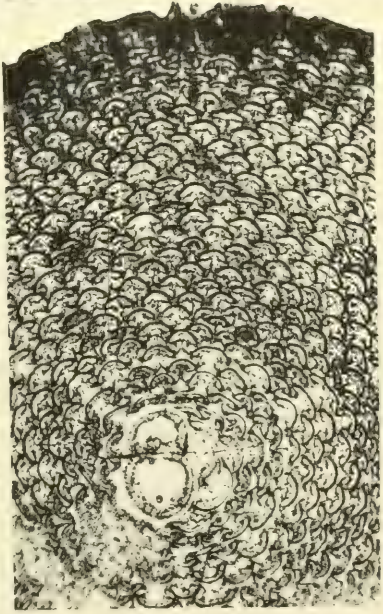
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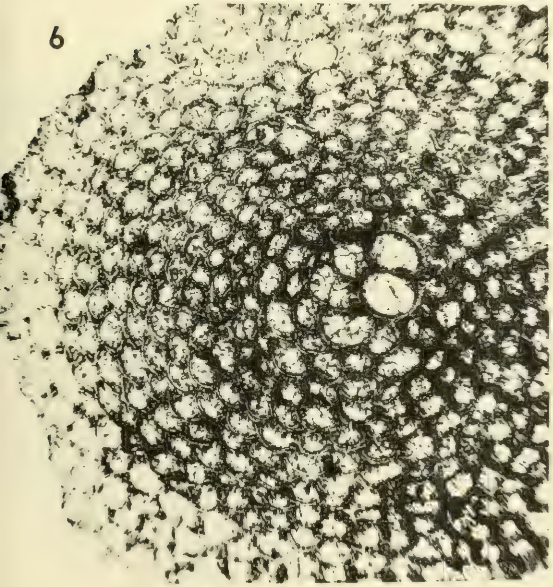
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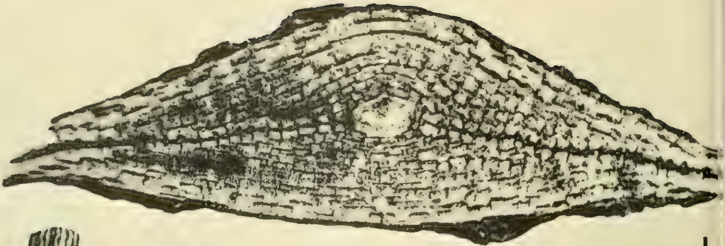
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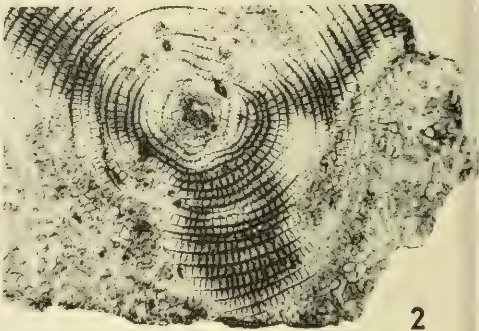
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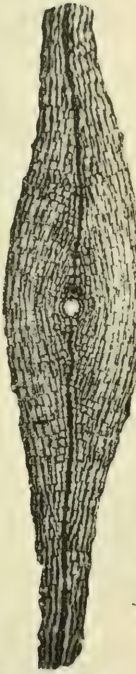
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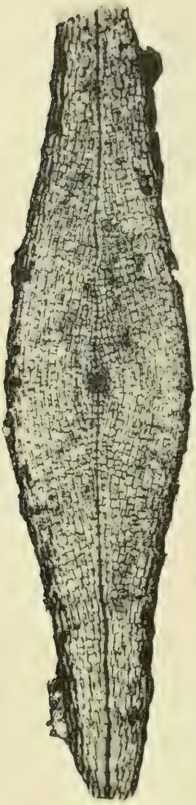
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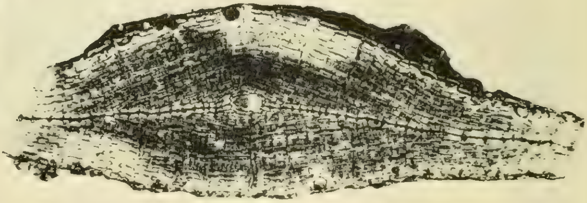
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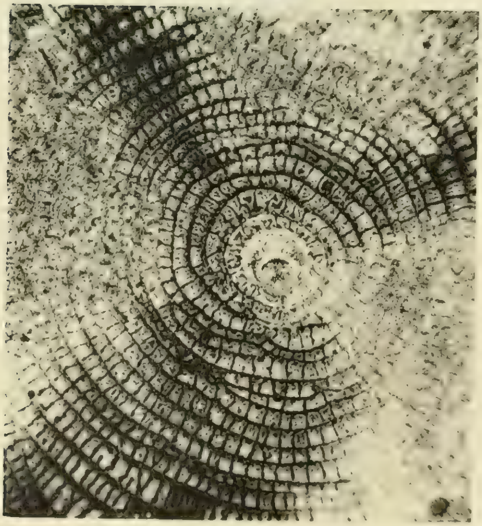
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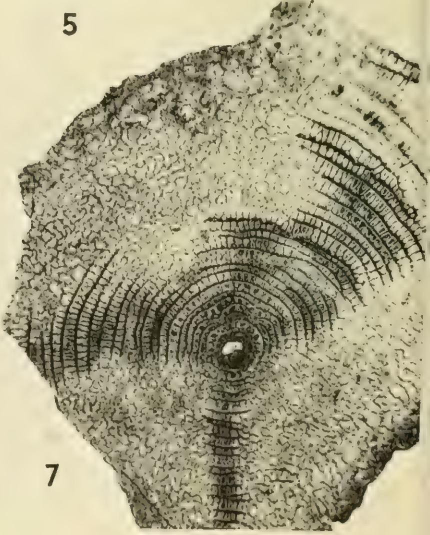
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EXPLANATION OF PLATE 8

Figure		Page
1-7.	**Pseudophragmina (Proporocyclina) teres** Cole and Gravell	29

1,3-5. Vertical sections; 1, X 40; 3-5, X 20.
2,6-7. Equatorial chambers; 2,7, X 20; 6, X 40.

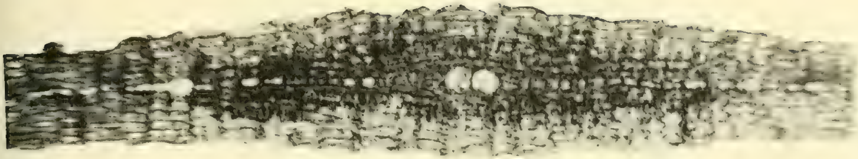
1,3,6. Loc. 13 at a depth of 1480-1500 feet.
2,4,5,7. Loc. 12 at a depth of 1410 feet.

EXPLANATION OF PLATE 9

Figure		Page
1-4.	**Pseudophragmina (Proporocyclina) clarki** (Cushman)	28
	1. Vertical section, X 40.	
	2. Vertical section, X 40, of a specimen with multiple sets of embryonic chambers.	
	3,4. Parts of equatorial sections, X 40.	
5, 6.	**Lepidocyclina (Polylepidina) antillea** Cushman	23
	5. Part of an equatorial section, X 40, of a specimen with two sets of embryonic chambers.	
	6. Part of an equatorial section, X 40, of a specimen with a single set of embryonic chambers.	

1-4. Loc. 11; 1,3,4, at a depth of 1300-1330 feet; 2, at 1000-1030 feet.

5,6. Loc. 6; 5, at a depth of 2340-2350 feet; 6, at 2200-2220 feet.



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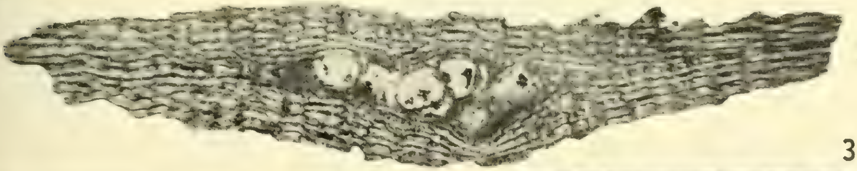

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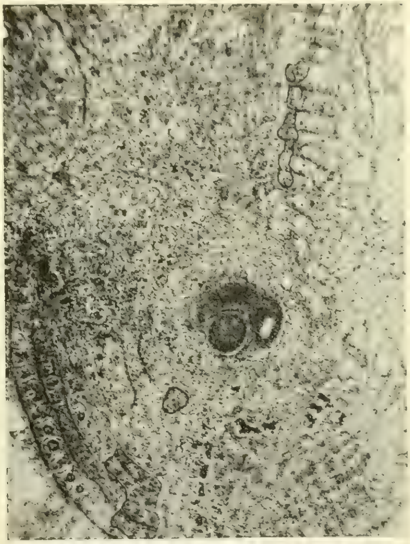

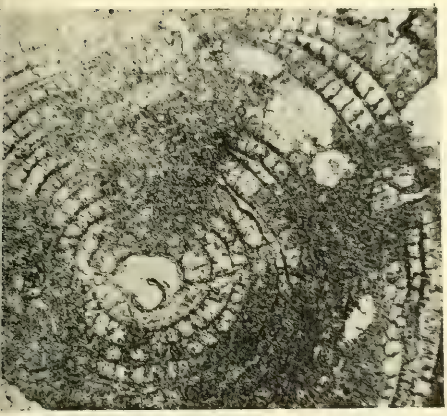

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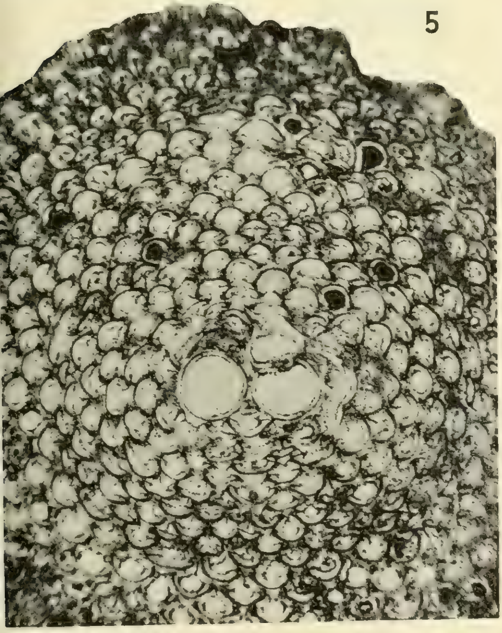

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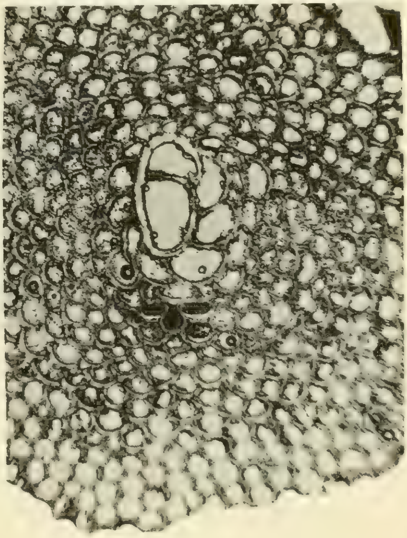

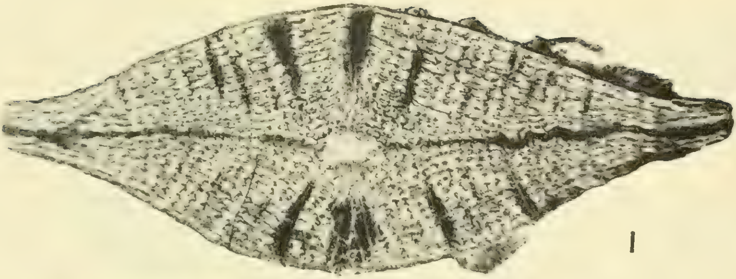
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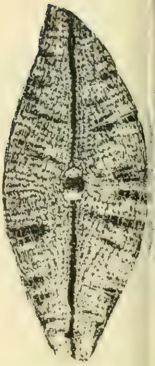
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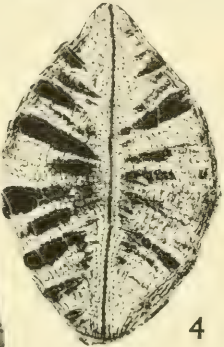
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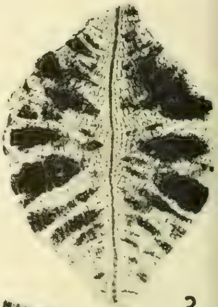
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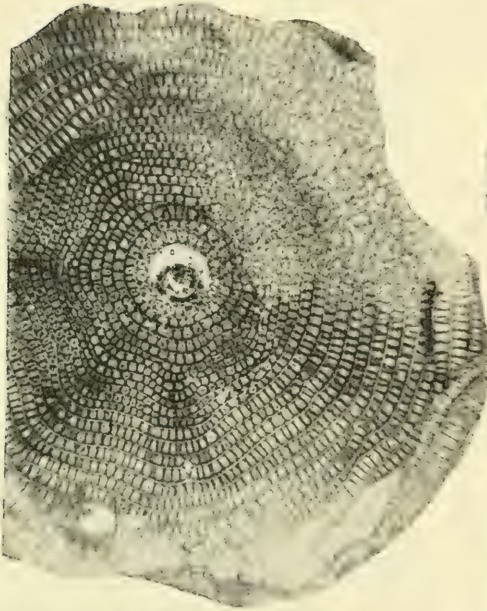
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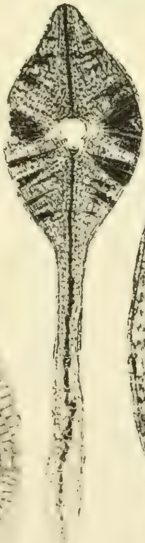
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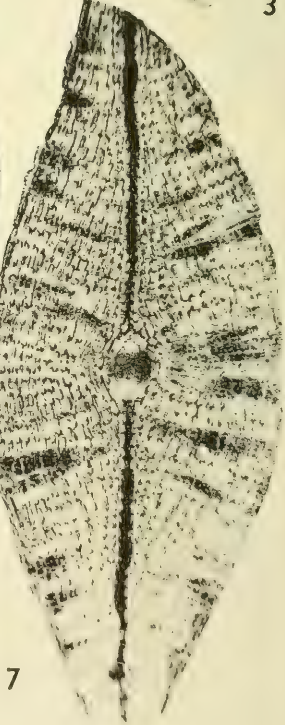
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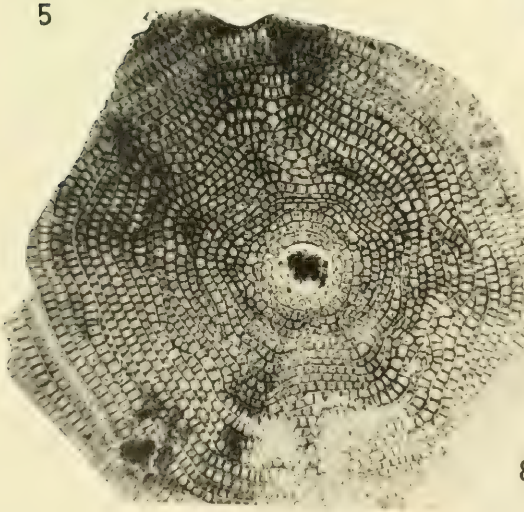
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EXPLANATION OF PLATE 10

Figure Page

1-8. **Discocyclina (Discocyclina) marginata** (Cushman) 21

1,2,6,7. Vertical sections of megalospheric specimens; 1,7, X 40; 2,6, X20; 2,7, the same specimen at different enlargements.

3,4. Vertical sections of microspheric specimens, X 20.

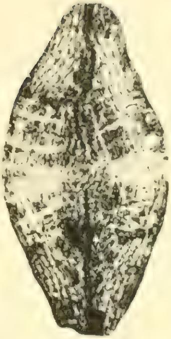
5,8. Equatorial sections, X 40.

1-8. Loc. 12 at a depth of 1690-1700 feet.

EXPLANATION OF PLATE 11

Figure		Page
1-3, 7-9.	**Discocyclina (Discocyclina) waltonensis** Cole and Applin, n. sp.	22
	1-3. Vertical sections, X 40. 7-9. Equatorial sections, X 40; 7, type.	
4-6, 10-12.	**Pseudophragmina (Proporocyclina) tobleri** Vaughan and Cole	29
	4-6,11,12. Vertical sections, X 40. 10. Equatorial section, X 40.	

1-10. Loc. 10 at a depth of 1752 feet.
11,12. Loc. 11 at a depth of 1600 feet.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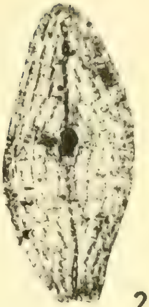
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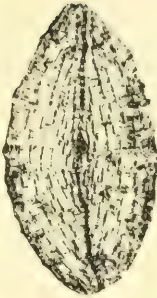
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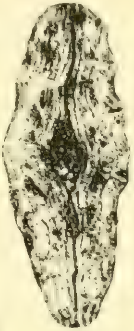
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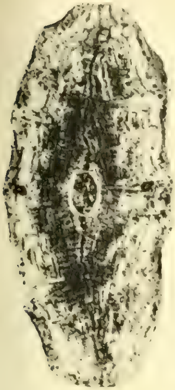
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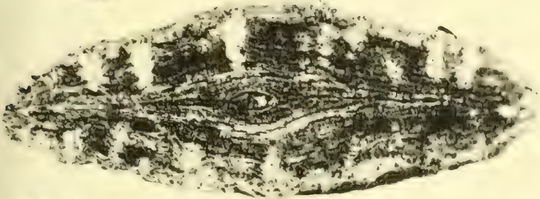
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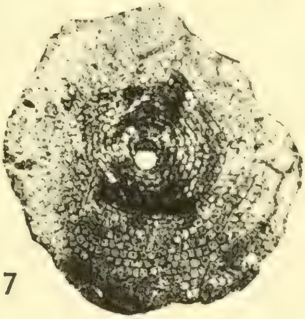
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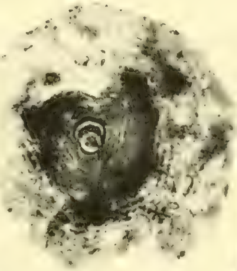
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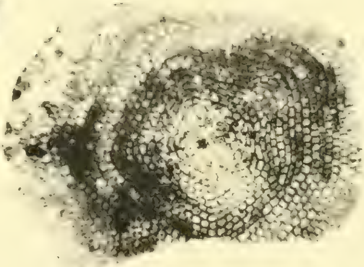
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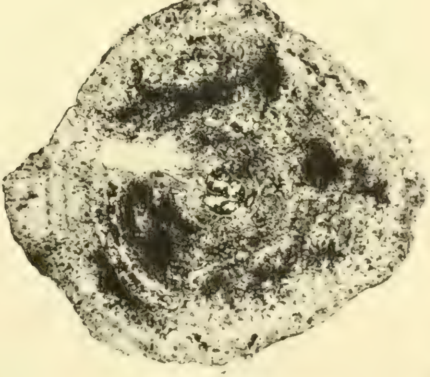
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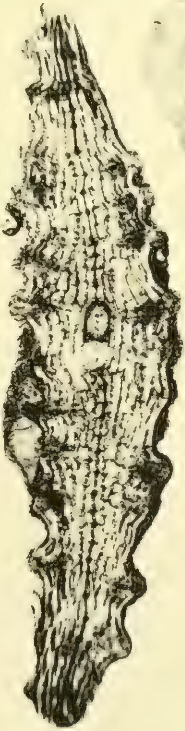
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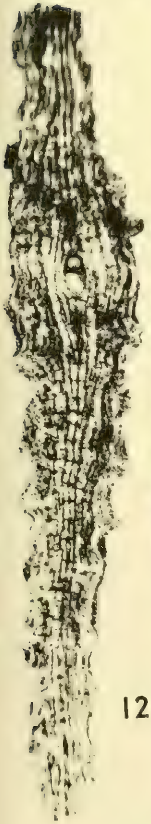
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DEVONIAN FORAMINIFERA: PART I, THE LOUISIANA LIMESTONE OF MISSOURI AND ILLINOIS

By

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and

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March 20, 1964

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APR 1 1964

This work is dedicated to
the late Colonel Lucien Beckner, D. Sc.,
Kentucky geologist and humanitarian
(1873-1963).

DEVONIAN FORAMINIFERA: PART I, THE LOUISIANA LIMESTONE OF MISSOURI AND ILLINOIS

James E. Conkin and Barbara M. Conkin
University of Louisville

ABSTRACT

The foraminiferal fauna of the Louisiana limestone of northeastern Missouri and western Illinois is described with the following taxa: five families, nine genera (*Crithionina, Thuramminoides, Amphitremoida, Psammosphaera?, Thurammina, Hyperammina, Oxinoxis, Aschemonella, Ammodiscus,* and *Tolypammina*), and 18 species (six new and four unidentifiable); *Oxinoxis* Gutschick, 1962, *O. ligula* (Gutschick, Weiner, and Young), 1961, and *Tolypammina bulbosa* (Gutschick and Treckman), 1959 are emended. One species, *Saccammina ligula* Gutschick, Weiner, and Young, 1961, is reallocated as the type species of the genus *Oxinoxis* Gutschick, 1962. Two species are placed in synonymy: *Tolypammina sperma* Gutschick, Weiner, and Young, 1961 is a junior subjective synonym of *T. jacobschapelensis* Conkin, 1961; *Tolypammina continuus* Gutschick, 1962 is a junior subjective synonym of *T. bulbosa* (Gutschick and Treckman), 1959. *Hyperammina sappingtonensis* Gutschick, 1962 is probably a junior subjective synonym of *H. kahlleitensis* Blumenstengel, 1961, but the synonymy is not formalized. *Amphicervicis* Mound, 1961 is probably congeneric with *Amphitremoida* Eisenack, 1937. This paper reports for the first time the occurrence of *Amphitremoida* in North America and of *Aschemonella* in the Paleozoic.

Although age determination of the Louisiana limestone based on arenaceous Foraminifera is difficult as a result of the occurrence in the Louisiana of species common to the Devonian and Mississippian and the fact that Devonian foraminiferal faunas are little known and are just beginning to be described, we are able to supply foraminiferal evidence which allows us to relegate the Louisiana limestone to the Upper Devonian.

The striking similarities between the foraminiferal faunas of the Louisiana limestone, the lower Sappington formation of Montana, and the McCraney limestone of Illinois are analyzed. Four genera and one species of arenaceous Foraminifera (*Ammobaculites, Trepeilopsis, Ammovertella, Reophax,* and *Hyperammina rockfordensis*) which occur widely and commonly in the Lower Mississippian of North America are not found in either the Louisiana or lower Sappington faunas. All of them, however, are found in the Hannibal formation which overlies the Louisiana, and *Ammobaculites, Reophax,* and *Trepeilopsis* have been found in the basal Lodgepole limestone which overlies the Sappington formation. We have, in our preliminary work on the McCraney limestone, recognized the genus *Ammobaculites* which serves to distinguish the Kinderhookian McCraney fauna from the Louisiana and lower Sappington faunas.

The lithographic aspect of the Louisiana limestone, the absence of any evidence of appreciable agitation of the bottom sediments during deposition, the general diminutive character of the macrofossils, the dolomitic nature of the intercalated thin shales and the upper beds of the limestone, and the limited geographic extent of the formation combine to supply evidence which lends itself to an interpretation of deposition of the Louisiana in a quiet and restricted environment of near shore, shallow, and tropical and somewhat hypersaline marine waters, perhaps lagoonal in nature; the water was charged with carbonates, and the bottom sediments were well aerated.

The lithographic limestone of the Louisiana contained rather modest amounts of fine silt grains which the arenaceous Foraminifera used to build their tests, and indeed, such sufficiency of adventitious particles in a sediment meets one requirement for the promotion of arenaceous foraminiferal life in some abundance (Conkin, 1961).

INTRODUCTION

Our first collections from the Louisiana limestone were made in the summer of 1958 when we sampled the Mississippian System of Missouri under a program initiated to describe the foraminiferal faunas of the type Mississippian of North America. Detailed sections of the Louisiana limestone at Louisiana and Hannibal, Missouri, and Teneriffe, Illinois, were measured in the spring of 1962, and at Hamburg, Illinois, in the summer of 1962.

Limestone samples were dissolved in dilute hydrochloric acid; samples from the few intercalated shales in the Louisiana were washed through a 200-mesh sieve. During this study we have not felt compelled to study the limestone in thin section in order to assess its foraminiferal content on fragmentary bases, but rather we wished to exemplify the fauna on the basis of the best preserved material that could be obtained. We are not depreciating the thin-section method in instances where calcareous forms are present or important, nor do we deny the inherent stratigraphic potentialities of the thin-section method in regard to the arenaceous Foraminifera (even in the case of the Louisiana limestone).

Photomicrographs were made with a Bausch and Lomb Stereo-Zoom microscope, a Nikon F-1 camera, Adox KB-14 film, and Kodabromide paper F-5; photographs are not retouched.

All figured specimens are deposited in the Cushman Collection, United States National Museum, Washington 25, D. C. The remaining specimens are retained by us.

ACKNOWLEDGMENTS

Funds for collecting and photography were available through National Science Foundation Research Grant No. G-15987, a larger program now underway to describe the arenaceous Foraminifera of the Silurian and Devonian of Kentucky and southern Indiana. We also wish to acknowledge financial aid from the Research Committee of the University of Louisville. Our sincere thanks go to Dr. Thomas Beveridge, State Geologist of Missouri, for initial support of field work during 1958, and to Drs. H. B. Willman and Charles W. Collinson of the Illinois Geological Survey, who supplied reprints of pertinent papers concerning the stratigraphy and age relationships of the Louisiana and McCraney limestones. Particular thanks go to Dr. William Huffman, Dean of the University

College of the University of Louisville, for support and encouragement of geological science here. Finally, we are grateful to Mr. James Pike, graduate student at the University of Louisville, for his pleasant company and efficient aid in measuring sections at Louisiana and Hannibal, Missouri.

PREVIOUS WORK

Early work on the Louisiana limestone was summarized by Williams whose study of the Louisiana stratigraphy and macrofauna (1943, 1957) is the most ambitious to date. We make no effort here to list or summarize previous work on the Louisiana but mention only those works which are particularly pertinent to the present study. Branson and Mehl (in Branson, *et al.,* 1938), Branson (1944), Scott (1961), and Scott and Collinson (1961) worked on the Louisiana conodont fauna. Conkin and Conkin (1964) briefly considered the Louisiana limestone and its correlation in their discussion of the Chouteau group of Missouri.

There has been no previous systematic description of the foraminiferal fauna of the Louisiana. The first report of Foraminifera in the Louisiana limestone was that of Williams (1943, pp. 29, 55) who indicated that Foraminifera were rare and listed three genera: *Hyperamminoides* (*Hyperammina* as emended by Conkin, 1954), *Lituotuba,* and *Ammodiscus.* Workman and Gillette (1956) identified the following six genera in the Louisiana: *Ammodiscus, Lituotuba, Hyperammina, Bathysiphon, Tolypammina,* and *Aschemonella?* and indicated that other genera were also present.

Gutschick (1962) in his work on the Foraminifera of the lower Sappington formation of Montana listed seven genera and nine species from the Louisiana limestone and remarked upon the similarity of the foraminiferal faunas of the lower Sappington and the Louisiana. The species reported by Gutschick from the Louisiana are: *Pseudastrorhiza delicata* Gutschick and Treckman, 1959, *Saccammina ligula* Gutschick, Weiner, and Young, 1961, *Hyperammina sappingtonensis* Gutschick, 1962, *Oxinoxis botrys* Gutschick, 1962, *Ammodiscus longexsertus* (Gutschick and Treckman), 1959, *Tolypammina continuus* Gutschick, 1962, and *T. extenda* Ireland, 1956. All species except *P. delicata* were also reported from the Sappington formation by Gutschick who also reported *Thuramminoides* sp. and *Lituotuba* sp. from the Louisiana limestone. We believe that the Sappington and Louisiana tolypamminid identified as *T. extenda* Ireland by Gutschick (1962) belongs to another species.

Figure 1 clarifies the taxonomic relationships between genera and species of Foraminifera in the Louisiana limestone as previously reported and the genera and species as interpreted by us. Details of taxonomic changes are discussed in the Systematic Paleontology portion of this paper.

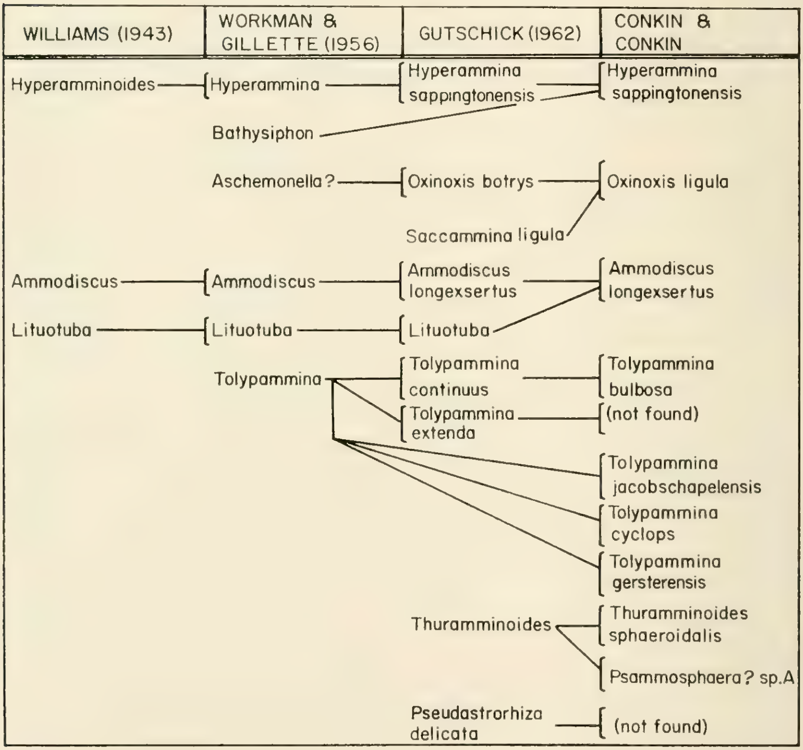

WILLIAMS (1943)
WORKMAN & GILLETTE (1956)
GUTSCHICK (1962)
CONKIN & CONKIN
Hyperamminoides
Hyperammina
Hyperammina sappingtonensis
Hyperammina sappingtonensis
Bathysiphon
Aschemonella?
Oxinoxis botrys
Oxinoxis ligula
Saccammina ligula
Ammodiscus
Ammodiscus
Ammodiscus longexsertus
Ammodiscus longexsertus
Lituotuba
Lituotuba
Lituotuba
Tolypammina
Tolypammina continuus
Tolypammina bulbosa
Tolypammina extenda
(not found)
Tolypammina jacobschapelensis
Tolypammina cyclops
Tolypammina gersterensis
Thuramminoides
Thuramminoides sphaeroidalis
Psammosphaera? sp.A
Pseudastrorhiza delicata
(not found)

Figure 1. Taxonomic relationships between genera and species of Foraminifera in the Louisiana limestone as previously reported and as interpreted in this paper.

PRESENT WORK

We will concern ourselves primarily with the systematic description of the foraminiferal fauna of the Louisiana limestone and secondarily with age assignment of the Louisiana based on the evolution of the arenaceous Foraminifera; paleoecological interpretations are briefly considered.

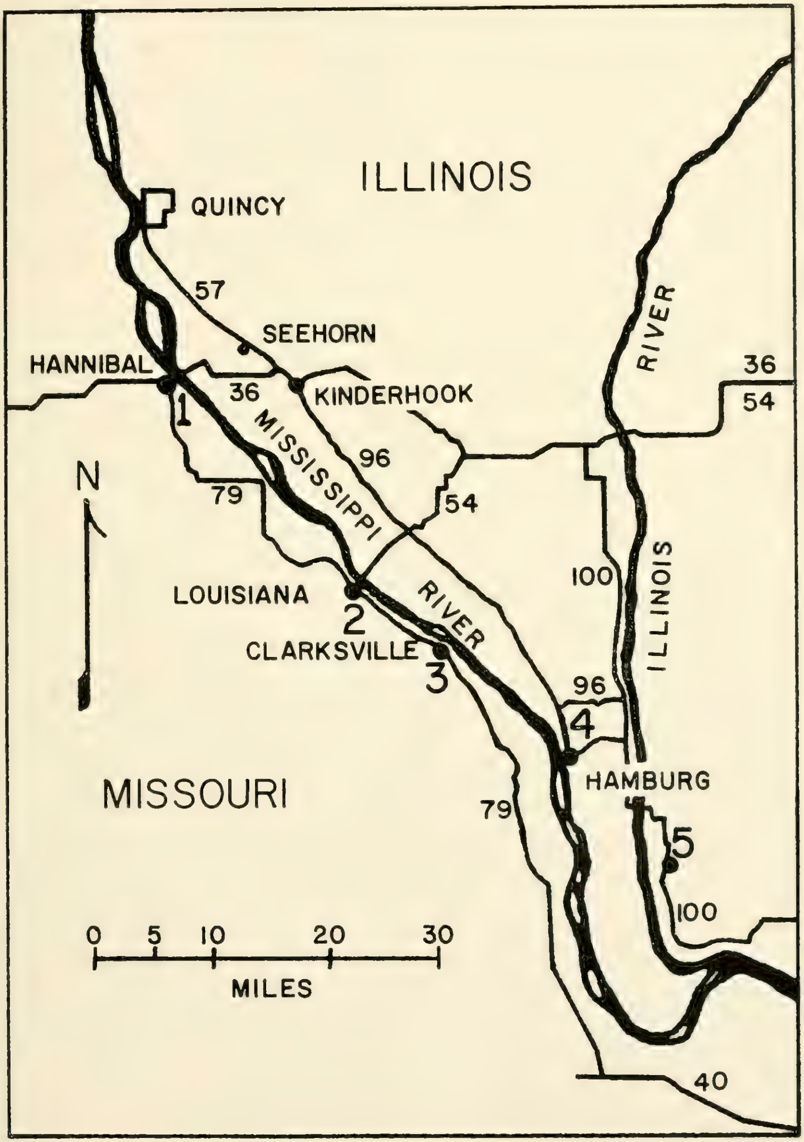

ILLINOIS
QUINCY
57
SEEHORN
HANNIBAL
36
KINDERHOOK
1
MISSISSIPPI
96
N
79
54
LOUISIANA
2
RIVER
CLARKSVILLE
3
100
ILLINOIS
RIVER
36
54
96
4
HAMBURG
5
100
79
MISSOURI
0
5
10
20
30
MILES
40

Figure 2. Location of measured sections and collecting sites.

LIST OF LOCALITIES

Collections were made from five localities (Figure 2). Thirty-seven samples were collected, and three sections were measured. All samples were found to contain Foraminifera. For details of lithology in the measured sections, see Figures 3-5.

Locality 1. Section measured at Lovers Leap, overlooking the railroad yards at Hannibal, Marion County, Missouri.

Locality 2. Section measured at Clinton Springs, Clinton Hill, just south of Noix Creek, on State Highway 79, at south edge of Louisiana, Pike County, Missouri.

Locality 3. Samples taken from the lower one-foot thick bed of the Louisiana limestone in road cut at the base of Pinnacle Hill, along State Highway 79, Clarksville, Pike County, Missouri.

Locality 4. Samples taken from the five-foot interval of the Louisiana limestone above the Saverton shale in the bank of Hamburg Creek, immediately behind the Methodist Church on High Street in Hamburg, Calhoun County, Illinois.

Locality 5. Section measured immediately east of State Highway 100, one-half mile south of Teneriffe School, Hardin Quadrangle, Jersey County, Illinois.

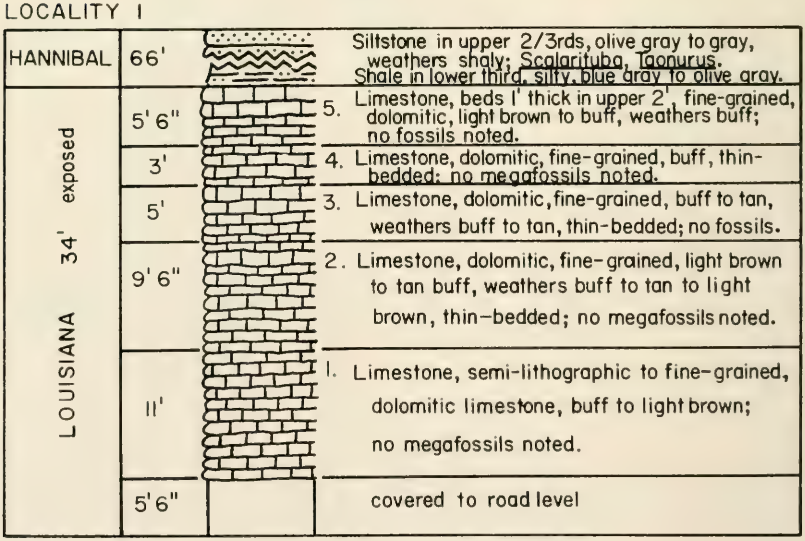
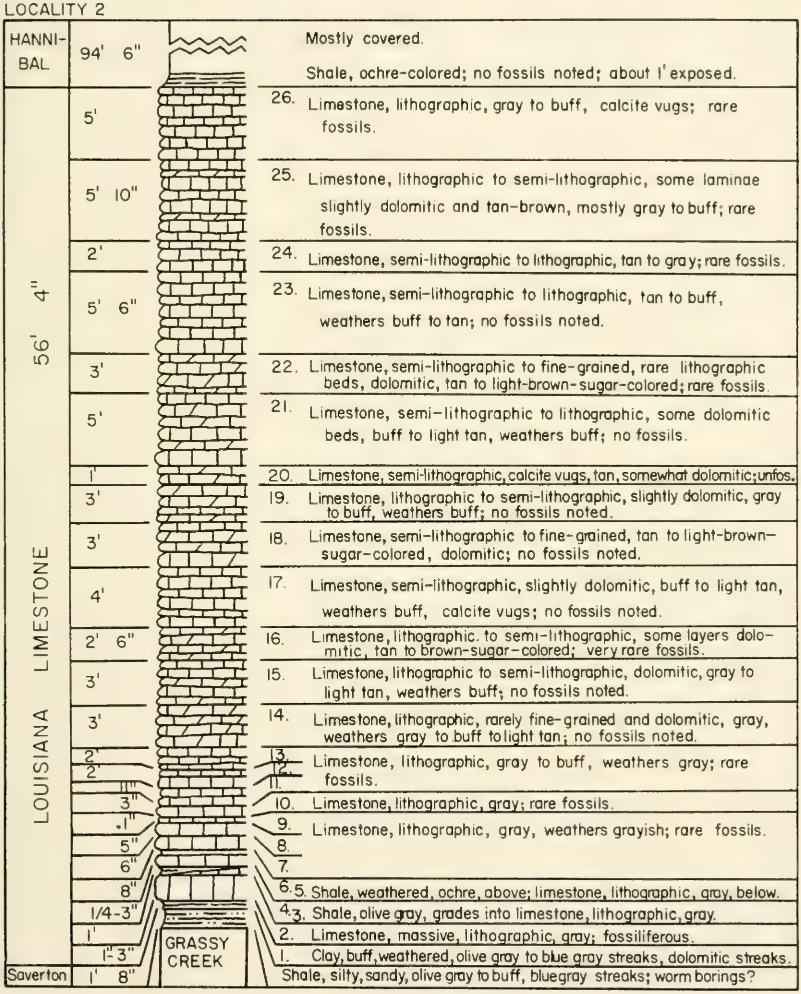

LOCALITY I
HANNIBAL
66'
Siltstone in upper 2/3rds, olive gray to gray, weathers shaly; Scalarituba, Taonurus.
Shale in lower third, silty, blue gray to olive gray.
LOUISIANA 34' exposed
5'6"
5. Limestone, beds 1' thick in upper 2', fine-grained, dolomitic, light brown to buff, weathers buff; no fossils noted.
3'
4. Limestone, dolomitic, fine-grained, buff, thin-bedded; no megafossils noted.
5'
3. Limestone, dolomitic, fine-grained, buff to tan, weathers buff to tan, thin-bedded; no fossils.
9'6"
2. Limestone, dolomitic, fine-grained, light brown to tan buff, weathers buff to tan to light brown, thin-bedded; no megafossils noted.
11'
1. Limestone, semi-lithographic to fine-grained, dolomitic limestone, buff to light brown; no megafossils noted.
5'6"
covered to road level

Figure 3. Measured section taken at Lovers Leap, Hannibal, Missouri.



Mostly covered.

Shale, ochre-colored; no fossils noted; about 1' exposed.

26. Limestone, lithographic, gray to buff, calcite vugs; rare fossils.

25. Limestone, lithographic to semi-lithographic, some laminae slightly dolomitic and tan-brown, mostly gray to buff; rare fossils.

24. Limestone, semi-lithographic to lithographic, tan to gray; rare fossils.

23. Limestone, semi-lithographic to lithographic, tan to buff, weathers buff to tan; no fossils noted.

22. Limestone, semi-lithographic to fine-grained, rare lithographic beds, dolomitic, tan to light-brown-sugar-colored; rare fossils.

21. Limestone, semi-lithographic to lithographic, some dolomitic beds, buff to light tan, weathers buff; no fossils.

20. Limestone, semi-lithographic, calcite vugs, tan, somewhat dolomitic; unfos.

19. Limestone, lithographic to semi-lithographic, slightly dolomitic, gray to buff, weathers buff; no fossils noted.

18. Limestone, semi-lithographic to fine-grained, tan to light-brown-sugar-colored, dolomitic; no fossils noted.

17. Limestone, semi-lithographic, slightly dolomitic, buff to light tan, weathers buff, calcite vugs; no fossils noted.

16. Limestone, lithographic to semi-lithographic, some layers dolomitic, tan to brown-sugar-colored; very rare fossils.

15. Limestone, lithographic to semi-lithographic, dolomitic, gray to light tan, weathers buff; no fossils noted.

14. Limestone, lithographic, rarely fine-grained and dolomitic, gray, weathers gray to buff to light tan; no fossils noted.

13.
12. Limestone, lithographic, gray to buff, weathers gray; rare fossils.
11.

10. Limestone, lithographic, gray; rare fossils.

9. Limestone, lithographic, gray, weathers grayish; rare fossils.
8.
7.

6. 5. Shale, weathered, ochre, above; limestone, lithographic, gray, below.

4. 3. Shale, olive gray, grades into limestone, lithographic, gray.

2. Limestone, massive, lithographic, gray; fossiliferous.

1. Clay, buff, weathered, olive gray to blue gray streaks, dolomitic streaks.

Shale, silty, sandy, olive gray to buff, bluegray streaks; worm borings?

Figure 4. Measured section taken at Clinton Springs, Louisiana, Missouri.

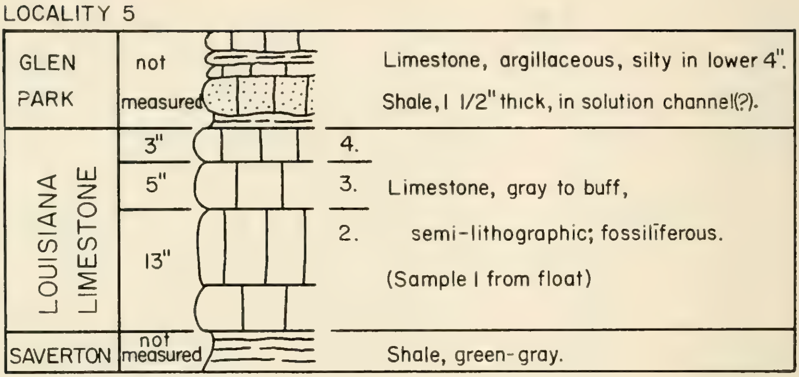

LOCALITY 5
GLEN PARK
not measured
Limestone, argillaceous, silty in lower 4".
Shale, 1 1/2" thick, in solution channel(?).
LOUISIANA LIMESTONE
3"
5"
13"
4.
3.
2.
Limestone, gray to buff,
semi-lithographic; fossiliferous.
(Sample 1 from float)
SAVERTON
not measured
Shale, green-gray.

Figure 5. Measured section taken near Teneriffe School, Illinois.

FAUNAL LIST

Our work on the Louisiana limestone shows that Foraminifera are common to abundant in insoluble residues of the limestone, particularly in the lower and less dolomitic portion at and near the type locality (Localities 2 and 3). Foraminifera are rare in the thin intercalated dolomitic shales.

The foraminiferal fauna of the Louisiana limestone consists of 18 species (six new and four unidentifiable) belonging to nine genera and five families; all are arenaceous forms.

Order FORAMINIFERA

Family **ASTRORHIZIDAE**

Genus **CRITHIONINA** Goës, 1894

C. psammosphaeraeformis, new species

Genus **THURAMMINOIDES** Plummer, 1945, emend. Conkin, 1961

T. sphaeroidalis Plummer, 1945, emend. Conkin, 1961

Genus **AMPHITREMOIDA** Eisenack, 1937

A. eisenacki, new species
A. huffmani, new species
A.? sp.

Family **SACCAMMINIDAE**

Genus **PSAMMOSPHAERA** Schultze, 1875

P.? sp. A
P.? sp. B
P.? sp. C

Genus **THURAMMINA** Brady, 1879

T. adamsi, new species
T. strickleri, new species

Family **HYPERAMMINIDAE**

Genus **HYPERAMMINA** Brady, 1878, emend. Conkin, 1954

H. sappingtonensis Gutschick, 1962

Family **REOPHACIDAE**

Genus **ASCHEMONELLA** Brady, 1879

A. louisiana, new species

Genus **OXINOXIS** Gutschick, 1962, emend.

O. ligula (Gutschick, Weiner, and Young), 1961, emend.

Family **AMMODISCIDAE**

Genus **AMMODISCUS** Reuss, 1862

A. longexsertus (Gutschick and Treckman), 1959

Genus **TOLYPAMMINA** Rhumbler, 1895

T. bulbosa (Gutschick and Treckman), 1959, emend.
T. cyclops Gutschick and Treckman, 1959
T. gersterensis Conkin and Conkin, 1964
T. jacobschapelensis Conkin, 1961

Five species, *Hyperammina sappingtonensis, Oxinoxis ligula, Ammodiscus longexsertus, Tolypammina jacobschapelensis,* and *Psammosphaera*? sp. A, were found together in at least 30 of the 37 samples studied. Occurring in fewer samples, but fairly commonly, are the following six species: *Amphitremoida huffmani, Thuramminoides sphaeroidalis, Thurammina adamsi, T. strickleri, Psammosphaera*? sp. B, and *Tolypammina*

LOCALITY	1					2																										3	4	5			
SAMPLE	1	2	3	4	5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	1	1	1	2	3	4
Thuramminoides sphaeroidalis						X	X		X														X		X								X	X	X		X
Crithionina psammo-sphaeraeformis	X						X																									X					
Amphitremoida eisenacki				X	X															X												X					
A. huffmani							X						X		X	X				X						X	X					X					
A. ? sp.							X	X																								X					
Psammosphaera ? sp. A	X		X			X	X	X	X	X	X	X	X		X	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
P. ? sp. B		X	X		X		X		X		X	X				X			X													X	X				
P. ? sp. C							X											X																			
Thurammina adamsi							X			X		X						X									X					X	X				
T. strickleri							X									X	X										X	X					X				
Hyperammina sappingtonensis	X		X	X			X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Aschemonella louisiana							X																									X					
Oxinoxis ligula	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Ammodiscus longexsertus	X	X	X	X		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Tolypammina bulbosa	X						X																											X			
T. cyclops							X																														
T. gersterensis							X									X			X													X		X			
T. jacobschapelensis	X		X	X			X	X		X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

Chart 1. Occurrence of Foraminifera in the Louisiana limestone of northeastern Missouri and western Illinois.

gersterensis. The remaining species in the faunal list occur rarely. Details of occurrence in the Louisiana limestone are given on Chart 1. Samples from measured sections are indicated on the occurrence chart by the same number as on the measured sections (Figures 3-5). Samples from the two unmeasured sections (Localities 3 and 4) are designated "1" on the occurrence chart.

AGE OF THE LOUISIANA LIMESTONE

PAST OPINION

Opinions as to the age of the Louisiana limestone have vacillated between Upper Devonian and Lower Mississippian (Kinderhookian) for more than a century since Swallow (1855) originally described the Louisiana as the "Lithographic" limestone and placed it at the base of his Devonian "Chemung" group. Meek and Worthen (1861) proposed the name Kinderhook for Swallow's inappropriately named Chemung group and placed it in the Carboniferous. Keyes (1892) gave the Louisiana its present name and included it in the Kinderhook although he believed (1892, p. 288) that the Louisiana would prove to be Devonian in age. During the following 40 years the age of the Louisiana was debated but was generally considered to be Kinderhookian. With the conodont work of Branson and Mehl (1933 and in Branson, *et al.*, 1938) the Louisiana was again placed in the Devonian.

Chart 2 shows the stratigraphic relationships of the formations considered in this paper in Missouri, Illinois, and Montana.

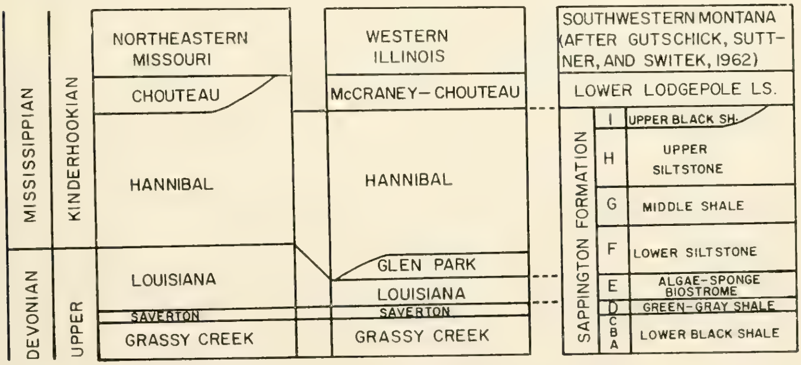

MISSISSIPPIAN
KINDERHOOKIAN
DEVONIAN
UPPER
NORTHEASTERN MISSOURI
CHOUTEAU
HANNIBAL
LOUISIANA
SAVERTON
GRASSY CREEK
WESTERN ILLINOIS
McCRANEY–CHOUTEAU
HANNIBAL
GLEN PARK
LOUISIANA
SAVERTON
GRASSY CREEK
SOUTHWESTERN MONTANA (AFTER GUTSCHICK, SUTTNER, AND SWITEK, 1962)
LOWER LODGEPOLE LS.
SAPPINGTON FORMATION
I
UPPER BLACK SH.
H
UPPER SILTSTONE
G
MIDDLE SHALE
F
LOWER SILTSTONE
E
ALGAE-SPONGE BIOSTROME
D
GREEN-GRAY SHALE
C
B
A
LOWER BLACK SHALE

Chart 2. Stratigraphic relationships of the formations in Missouri, Illinois, and Montana which are considered in this paper.

Various lines of evidence for assigning the Louisiana to either the Kinderhookian or Upper Devonian were presented by Williams (1943) whose work was largely done prior to 1933. Williams' conclusion as to the age of the Louisiana favored the Kinderhookian primarily on the basis of the overall aspect of the macrofauna. We should be inclined to agree with Williams' age assignment on the basis of the macrofossils; however, Williams (1943, p. 38) noted that the faunas are, in part at least, facies controlled and he discussed at some length the faunas reported from the Glen Park, Louisiana, and Saverton as time markers and facies indicators:

> If it is correct [rocks of different lithologic characters were deposited at the same time], conspicuous differences between faunas within the Kinderhookian may be more correctly ascribed to facies and environmental differences than to time differences; and correlations based solely on numerical superiority of common species or genera of fossils will not be reliable. The difficulty of making close faunal correlation of the Louisiana with other Kinderhookian formations [Williams considered the Louisiana to be early Mississippian in age] is in part also caused by the lack of published recent work on the descriptive paleontology and the zonal distribution of the fossils of these other formations. The deficiency of recent published work of this type for the Hannibal and Chouteau formations in Missouri and the formations exposed at Kinderhook, Ill., and at Burlington, Iowa, especially hinders the correlation of the Louisiana.

It may be noted here that our plan to describe the foraminiferal fauna of each Mississippian formation in the type area is in the spirit of the above statement; Part I, the Northview formation of Missouri, is already published (Conkin and Conkin, 1964). Five more parts of this series are nearing completion: the Hannibal, Chouteau, Fern Glen, Pierson, and McCraney.

Williams considered the Louisiana limestone to be Kinderhookian (1943, p. 47) and equivalent to part of the lower Waverly, particularly the Berea sandstone. Conkin (1961) made an intensive study of the Waverly rocks in southcentral Ohio and their equivalent beds in Kentucky, southern Indiana, and northern Tennessee and presented descriptions of foraminiferal faunas different from the foraminiferal fauna of the Louisiana limestone. Of course, there are no Devonian or Lower Mississippian rocks to be found in the eastcentral United States which even approximate the lithology of the Louisiana limestone except the Rockford limestone, but the foraminiferal fauna of the Rockford of northern Indiana (Gutschick and Treckman, 1959) and of southern Indiana (Conkin, 1961) is different from that of the Louisiana limestone.

Of interest is Williams' statement (1943, p. 48) that the Louisiana macrofauna has closer affinities to the Middle Devonian (Hamilton) faunas of the eastern United States than to the Upper Devonian faunas of eastern United States. Williams pointed out that H. S. Williams and others believed that faunal elements of the Hamilton "recur" in several horizons in the Upper Devonian and that these Hamilton faunas perhaps migrated westward to become the progenitors of the Saverton shale-Louisiana limestone faunas. We find one prominent element of the Hamilton foraminiferal faunas (*Oxinoxis ligula*) in the Louisiana foraminiferal fauna.

Branson and Mehl (in Branson, *et al.*, 1938) and Branson (1944), primarily on the basis of the geologic range of conodonts, placed the Louisiana in the Devonian, with the Devonian-Mississippian boundary at the base of the Bushberg-Hannibal sequence. Mehl (1960, p. 70) indicated that the so-called Bushberg is not all of the same age everywhere, and he would restrict the name Bushberg to its type area where it is Late Devonian in age; Mehl proposed the name Bachelor for the basal Mississippian sandstone and considered the Louisiana limestone to be probably of Late Devonian age.

Weller, *et al.*, (1948) placed the Louisiana in the Fabius group of Devonian or Mississippian age.

The most recent age determination of the Louisiana limestone comes from the conodont studies of Scott (1961), Scott and Collinson (1961), and Collinson, Scott, and Rexroad (1962) which present evidence supporting a Late Devonian age for the Louisiana limestone.

Conodont workers rely rather heavily on European conodont zones and their relationships to goniatite zones for placement of the Devonian-Mississippian boundary. Collinson, Scott, and Rexroad (1962, p. 10) believe that the *Gnathodus kockeli-G.*, n. sp. B zone in the lowermost Hannibal and "Glen Park" formations is roughly a time equivalent to the *Gnathodus kockeli-Pseudopolygnathus dentilineata* zone of Voges (lower part of the *Gattendorfia* Stufe, cuI) and indeed call the "Glen Park"—lowermost Hannibal fauna the *Gnathodus kockeli-Pseudopolygnathus dentilineata* fauna of Voges (1962, p. 14); however, *G. kockeli* first appears in the Louisiana and uppermost Saverton. It is, in large measure, the absence of the Lower Mississippian conodont genera, *Siphonodella, Elictognathus,* and *Pseudopolygnathus,* that has indicated relegation of the Louisiana to the Upper Devonian (*Wocklumeria* Stufe, toVI) (Scott and Collinson, 1961, p. 117); however, such age assignment is tentative inasmuch as the equivalent of the Louisiana-upper Saverton conodont fauna has not been reported from Germany, but the Louisiana-upper Saverton may "represent the time equivalent of the unfossiliferous portion of the Hangenberg-Schichten of the Rheinisch Schiefergebirge that lies between the highest occurrences of *Wocklumeria* and the lowest occurrence of *Gattendorfia*" (Collinson, Scott, and Rexroad, 1962, p. 14) in Germany, the standard reference area for conodont zonation in Europe.

PRESENT OPINION

Attempts to judge the age of the Louisiana limestone by means of its contained arenaceous Foraminifera are beset with difficulties in common with age determinations of the Louisiana on the basis of the macrofossils and conodonts, in that some Louisiana foraminiferal species are known from the Devonian as well as the Lower Mississippian. Furthermore, the Devonian foraminiferal faunas of North America are little known and their descriptions have only begun.

The known geologic ranges of previously described Foraminifera which occur in the Louisiana are given in Chart 3. No formerly described Louisiana species is known to be restricted to strata of Devonian age; however, two species from the Louisiana fauna are known to range into definite Devonian beds: *Thuramminoides sphaeroidalis* which occurs widely from Silurian through Permian (Conkin, 1961, p. 245) and *Oxinoxis ligula,* which we have found well represented in the Middle Devonian (Hamilton) Sellersburg formation in Kentucky and southern Indiana. A third species, *Hyperammina sappingtonensis* Gutschick, 1962, originally described from the lower Sappington formation of Montana, is almost certainly a junior subjective synonym of *H. kahlleitensis* Blumenstengel, 1961 which was described from the undoubted Upper Devonian of Germany; however, discrepancies between the measurements and figures of *H. kahlleitensis* preclude formal recognition of this probable synonymy at present.

Tolypammina gersterensis and *T. jacobschapelensis* have previously been found only in the Lower Mississippian.

The three remaining species (*Ammodiscus longexsertus, Tolypammina bulbosa,* and *T. cyclops*) on Chart 3 were formerly known from only the Lower Mississippian and the lower Sappington formation (subunit E, the algae-sponge biostrome of Gutschick, Suttner, and Switek, 1962) of Montana.

The age of subunit E of the Sappington has not been definitely determined, whether Lower Mississippian or Upper Devonian, but Gutschick (1962) noted the similarity between the foraminiferal faunas of subunit E of the lower Sappington and the Louisiana limestone of Missouri. Although the foraminiferal faunas are indeed similar (the Louisiana fauna, according to our interpretation of Gutschick's work, contains five of the six definitely identified species from the Sappington), the Louisiana fauna is apparently larger in number of species and individuals. We have begun a study of the Foraminifera of the McCraney limestone of Illinois and Iowa and have, after preliminary study, found several of the same species in the McCraney limestone at Seehorn Creek, about one-half mile north of Seehorn, Illinois (Figure 2), that are found in the Louisiana and Sapping-

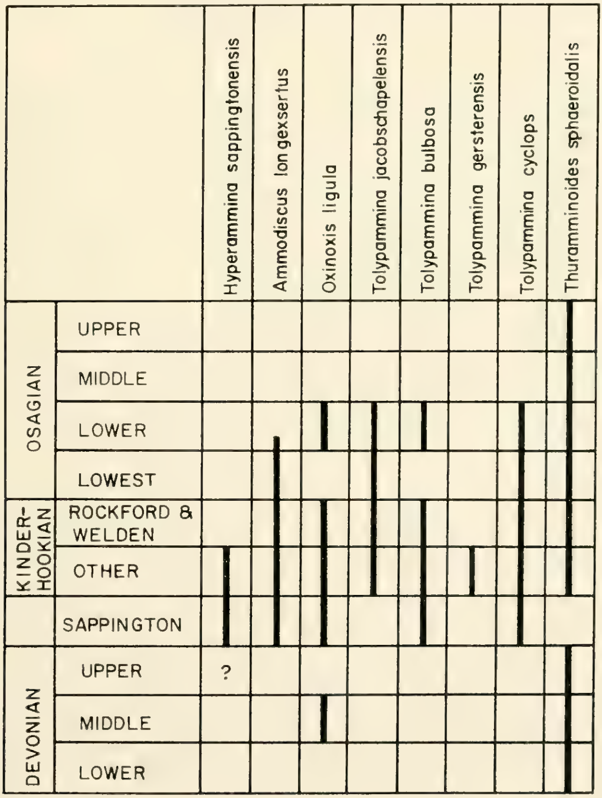


Chart 3. Occurrence in the Devonian, Kinderhookian, and Osagian of previously described Foraminifera which are found in the Louisiana limestone.

ton. The McCraney fauna consists of *Oxinoxis ligula, Hyperammina sappingtonensis, Tolypammina bulbosa, T. cyclops, Ammodiscus longexsertus, T. jacobschapelensis, Psammosphaera?* sp., and *Ammobaculites* sp.; the first five species occur in the Sappington and all but *Ammobaculites* are found in the Louisiana. Thus, while the Sappington foraminiferal fauna is similar to the Louisiana foraminiferal fauna, it is also similar to the McCraney foraminiferal fauna.

Gutschick (1962) accepted a Lower Mississippian age for the Sappington formation, but subsequently Gutschick, Suttner, and Switek (1962) suggested an Upper Devonian age for the lower part of the Sappington (subunits A-E) largely on the basis of the similarity of the foraminiferal fauna of subunit E of the lower Sappington to the foraminiferal fauna of the Louisiana limestone. As noted under "Past Opinion," the Louisiana limestone has been placed tentatively in the Upper Devonian on the basis of conodonts by Scott (1961), Scott and Collinson (1961), and Collinson, Scott, and Rexroad (1962). Inasmuch as the Sappington foraminiferal fauna is also similar to the Kinderhookian McCraney foraminiferal fauna, the resemblance between the Louisiana and Sappington foraminiferal faunas might seem less significant. Still, several genera of arenaceous Foraminifera which occur rather widely and commonly in the Mississippian of North America are not found in either the Louisiana or lower Sappington faunas; these genera are: *Ammobaculites, Trepeilopsis, Ammovertella,* and *Reophax.* All of these genera are found in the Kinderhookian Hannibal formation (Conkin, Conkin, and Pike, in manuscript) which overlies the Louisiana and underlies the McCraney, and all except *Ammovertella* occur in the basal Lodgepole limestone which overlies the Sappington formation (Gutschick, Weiner, and Young, 1961). We believe that the upper Sappington (subunits F-H) above the algae-sponge biostrome may be found to contain at least some of these Lower Mississippian Foraminifera. This upper shale-siltstone portion of the Sappington was noted by Gutschick, Suttner, and Switek (1962) to resemble the Hannibal formation in lithology and fauna.

As noted earlier in this discussion, we have found the genus *Ammobaculites* in the McCraney foraminiferal fauna; thus, in preliminary study, the McCraney fauna is distinguishable from the Louisiana and Sappington faunas.

We do not know of any record of *Ammobaculites, Trepeilopsis, Ammovertella,* or *Reophax* in pre-Mississippian rocks in North America;

however, *Ammovertella* and *Reophax* have been reported from the Devonian of Eastern Europe (*fide* Toomey, 1961, 1963).

To our minds, the absence in the Louisiana limestone of a species of *Hyperammina, H. rockfordensis* Gutschick and Treckman, 1959, is significant. *H. rockfordensis* is widely distributed geographically and of common occurrence in Kinderhookian rocks (limestones as well as shales) in the United States, from Kentucky to New Mexico, but this species has not been found in the Louisiana or lower Sappington faunas. *H. rockfordensis* does occur in the Hannibal formation (unpublished manuscript). It has been reported in the Upper Devonian only as a single occurrence in the Blackiston member of the New Albany shale in eastern Kentucky (Conkin, 1961, p. 269, Charts 8, 17, 22). In addition, Blumenstengel reported a single specimen of *H. rockfordensis* in the German Upper Devonian.

In conclusion then, we, like the conodont workers who tentatively place the Louisiana in the Upper Devonian partly on the absence of Lower Mississippian conodont genera, place the Louisiana in the Upper Devonian largely on the basis of absence of the aforementioned post-Devonian Foraminifera, *Ammobaculites, Reophax, Trepeilopsis, Ammovertella,* and *Hyperammina rockfordensis.*

PALEOECOLOGY

The lithographic character of the bulk of the Louisiana limestone, the absence of any real evidence of agitated waters, the predominance of diminutive elements of the macrofauna, the dolomitic nature of the intercalated thin shales, and the limited geographic extent of the Louisiana limestone point to deposition of sediments in a quiet and restricted environment of near shore, shallow, tropical, and probably hypersaline marine water, perhaps lagoonal in nature. This interpretation as to the nature of the environmental conditions prevailing during the time of deposition of the Louisiana limestone is consistent with hypotheses concerning the paleogeography as outlined by Williams (1943, pp. 49-52). The bottom water and immediately underlying sediments were undoubtedly well oxygenated as there is an absence of incompletely oxidized organic material and there is no evidence in the limestone of stagnation. The source area for the Louisiana sediments must have been composed largely of carbonate rocks inasmuch as the insoluble residues of the limestone beds of the Louisiana are small in quantity, being composed mostly of gray-cream argillaceous matter, orangish-red oxides of iron, and small silt-sized grains of quartz.

Rather good ecological conditions for the promotion of foraminiferal life were present on the sea bottom during Louisiana sedimentation. The fine-grained silt in the calcareous mud was available to the arenaceous Foraminifera for construction of their grainy tests. The abundance of carbonates in the water was not harmful to foraminiferal life nor was the presence of iron ions detrimental.

We are not concerned here with the nature of the original cement secreted by the protoplasm of the Foraminifera; our thoughts on this matter have been presented previously (Conkin, 1961, pp. 235, 236, 255-260, 275-277, 318-321). The point which we wish to stress now is that arenaceous Foraminifera must have grains of silt or sand-sized particles with which to construct their tests, regardless of type of original cement secreted by the protoplasm. We have found in the central and eastcentral United States that extremely pure calcium carbonate limestones, with virtually no siltaceous or fine arenaceous particles, contain no or nearly no arenaceous Foraminifera, whereas sediments (either shales or carbonates) which contain proportionally moderate or even modest amounts of siltaceous or fine arenaceous particles are apt to contain arenaceous Foraminifera in greater or lesser numbers (some sediments are of course barren of arenaceous Foraminifera for other and various ecological reasons). The relative abundance of arenaceous Foraminifera in the Louisiana limestone thus substantiates the conclusion reached by Conkin (1961, pp. 233, 234) concerning the relationship of lithology to the probability of occurrence of arenaceous Foraminifera in Paleozoic sedimentary rocks.

SYSTEMATIC PALEONTOLOGY

Order FORAMINIFERA

Family **ASTRORHIZIDAE**

Genus **CRITHIONINA** Goës, 1894

Crithionina psammosphaeraeformis, new species Pl. 12, figs. 12-15

Description.—Test free, subspherical, globose to tumidly discoidal; apertures large, rounded or with rough margins, rather irregularly placed or situated somewhat equatorially on some specimens, and numbering from two or three to ten? or more; interior of test labyrinthic with irregular partitions of adventitious material in the form of pillar-like structures between the labyrinthic passages; exterior of test smooth, of fine siliceous grains in siliceous cement; color of test, white to buff.

Measurements.—See Table 1 for measurements of *Crithionina psammosphaeraeformis,* and Table 2 for range in measurements.

Table 1. Measurements of figured specimens of *Crithionina psammosphaeraeformis,* in mm.

Plate 12	max. diam.	min. diam.	thickness	diam. of apertures	locality and sample numbers
fig. 12	.218	.185	.151	.025-.042	2 - 2
fig. 13	.193	.185	.151	.025-.050	3 - 1
fig. 14	.193	.185	.151	.017-.025	3 - 1
fig. 15	.190	.185	.160	.017-.025	1 - 1

Table 2. Range in measurements of nine specimens of *Crithionina psammosphaeraeformis,* in mm.

max. diam.	.143-.218
min. diam.	.126-.185
thickness	.101-.160
diam. apertures	.017-.050

Comparison and affinities.—*Crithionina psammosphaeraeformis* differs from all other species of *Crithionina* in possessing a regularly shaped test like that of a *Psammosphaera,* in having more regularly rounded apertures, and a smoother exterior.

Type locality.—The holotype is from the lower one-foot-thick bed (sample 2) of the Louisiana limestone at Locality 2 at Louisiana, Missouri.

Stratigraphic occurrence.—*Crithionina psammosphaeraeformis* was found in the Louisiana limestone in three samples from three localties; all occurrences are from the lowermost part of the Louisiana limestone. See Chart 1 for details of occurrence.

Remarks.—The genus *Crithionina* has been divided into three genera by Loeblich and Tappan (1961, pp. 217, 218) ; however, at this time the exact relationships between the three are not clear to us. Although the present species may belong in *Daitrona* Loeblich and Tappan, 1961, we place this new species in *Crithionina s. 1.*

Genus **THURAMMINOIDES** Plummer, 1945, emend. Conkin, 1961

Thuramminoides sphaeroidalis Plummer, 1945, emend. Conkin, 1961

Pl. 12, figs. 36-38

Thuramminoides sphaeroidalis Plummer, 1945, Univ. Texas, Pub. 4401, pp. 218, 219, pl. 15, figs. 4-10; Crespin, 1958, [Australia] Bur. Mineral Res., Geol. and Geophys., Bull. 48, pp. 40, 41, pl. 3, figs. 9-11; pl. 31, figs. 1, 2; Conkin, 1961, Bull. Amer. Paleont., vol. 43, No. 196, pp. 243-247, pl. 17, figs. 1-10; pl. 18, figs. 1-4; pl. 26, figs. 1-3; Fig. 1; Conkin, Conkin, and McDonald, 1963, Micropaleont., vol. 9, No. 2, p. 221, pl. 1, figs. 16, 17; Conkin and Conkin, 1964, Micropaleont., vol. 10, No. 1, p. 32, pl. 1, figs. 51-54.

Thuramminoides teicherti (Parr), Crespin, 1958, [Australia] Bur. Mineral Res., Geol. and Geophys., Bull. 48, pp. 41, 42, pl. 3, figs. 12, 13.

Description.—Test free, unilocular, originally spherical, but preserved as flattened disk to lens-shaped, roughly circular forms; vestiges of the internal centripetal tube structure may be seen on the interior surface of broken tests in the form of small pitlike depressions; test wall thin where internal structure is destroyed, to moderately thick, and composed of fine siliceous grains in a moderate to large amount of siliceous cement; color of test, white to gray to buff.

Measurements.—See Table 3 for measurements of *Thuramminoides sphaeroidalis* and Table 4 for comparison with previously described forms.

Table 3. Measurements of figured specimens of *Thuramminoides sphaeroidalis,* in mm.

Plate 12	min. diam.	max. diam.	thick-ness	locality and sample numbers
fig. 36	.586	.640	-	4 - 1
fig. 37	.302	.344	.084	2 - 4
fig. 38	.537	.586	.201	2 - 1

Table 4. Range in measurements of five specimens of *Thuramminoides sphaeroidalis,* in mm.

max. diam.	.344-.660
min. diam.	.302-.640
thickness	.084-.201

Comparison and affinities.—The specimens of *Thuramminoides sphaeroidalis* from the Louisiana limestone are identical in all respects with previously described specimens.

Gutschick (1962, p. 1294) reported *Thuramminoides* to be "common" in the Louisiana limestone. Inasmuch as we found *T. sphaeroidalis* rather uncommonly in the Louisiana, it is possible that Gutschick's reference may actually be to another more common form which we have tentatively placed in *Psammosphaera?* sp. A; this latter form externally resembles *Thuramminoides,* but lacks the internal structure of *Thuramminoides.*

Stratigraphic occurrence.—Thuramminoides sphaeroidalis ranges from the Middle Silurian to the Permian (Conkin, 1961). It was found in nine samples of the Louisiana limestone from four localities, but nowhere in abundance. See Chart 1 for details of occurrence.

Genus **AMPHITREMOIDA** Eisenack, 1937

Amphitremoida eisenacki, new species Pl. 12, figs. 8-10

Description.—Test free, consisting of a single fusiform chamber with a small aperture at each end; all tests presently compressed; length/width ratio of test ranges from 2.09 to 3.10; apertural ends of test somewhat extenuated but are blunt immediately adjacent to the apertural opening; wall smooth to slightly rough, composed of fine siliceous grains in siliceous cement; color of test, white to pale rusty white.

Measurements.—See Table 5 for measurements of *Amphitremoida eisenacki,* and Table 6 for comparison with *A. citroniforma* Eisenack, 1937 and *A. huffmani,* new species.

Table 5. Measurements of figured specimens of *Amphitremoida eisenacki,* in mm.

Plate 12	length	diam.	thickness	diam. apertural ends	length/ width	locality and sample nos.
fig. 8	.745	.244	.109	.067, .084	3.10	1 - 5
fig. 9	.554	.218	.118	.058, .033	2.55	1 - 4
fig. 10	.525	.201	.118	.050, .084	2.68	2 - 15

Table 6. Range in measurements of six specimens of *Amphitremoida eisenacki* and comparison with measurements of 28 specimens of *A. huffmani,* and with *A. citroniforma* Eisenack, 1937, in mm.

	A. eisenacki	*A. huffmani*	*A. citroniforma*
length	.319-.745	.185-.235	.180-.360
diameter	.134-.244	.095-.176	.120-.240
length/width	2.09-3.10	1.34-2.15	1.28-2.10
diam. apert. ends	.033-.084		

Comparison and affinities.—*Amphitremoida eisenacki* differs from previously described species of *Amphitremoida* in being proportionately more slender and in having more extenuated apertural ends. In addition, *A. eisenacki* is larger than other species of *Amphitremoida,* except for *A*? sp.

Type locality.—The holotype is from sample 4 of the Louisiana limestone at Locality 1, Hannibal, Missouri.

Stratigraphic occurrence.—This is the first definite notice of the genus *Amphitremoida* in North America. We have found *Amphitremoida* in the Silurian of Kentucky and believe the new genus *Amphicervicis* Mound, 1961 is a junior subjective synonym of *Amphitremoida* Eisenack, 1937; this subject will be considered in detail in our future paper on the Silurian and Devonian Foraminifera of Kentucky and southern Indiana.

Amphitremoida eisenacki was found rarely in the Louisiana limestone in four samples from three localities. See Chart 1 for details of occurrence.

Remarks.—*Amphitremoida* is given incorrectly as *Amphitremoidea* by Cushman (1948, p. 72) ; there has been a recent usage of Cushman's erroneous spelling.

This species is named for Professor Doctor Alfred Eisenack in recognition of his efforts to make known the microfauna of the Lower Paleozoic of Europe and for his kindness to us during preparation of this paper.

Amphitremoida huffmani, new species Pl. 12, figs. 1-7

Description.—Test free, consisting of a single fusiform chamber with a small round aperture at each end; length/width ratio of test ranges from 1.34 to 2.15; some tests are compressed, producing a greater width in proportion to the length than the test would have had in its original condition; uncompressed tests have a length/width ratio of 1.46 to 1.91; ends of test slightly blunt around the apertures; wall smooth, composed of fine siliceous grains in siliceous cement; color of test, white to pale rusty white.

Measurements.—See Table 7 for measurements of *Amphitremoida huffmani,* and Table 6 for comparison with *A. citroniforma* Eisenack, 1937 and *A. eisenacki,* new species.

Table 7. Measurements of figured specimens of *Amphitremoida huffmani,* in mm.

Plate 12	length	diam.	thickness	length/width	locality and sample numbers
figs. 1a,b	.235	.151	.134	1.56	2 - 21
figs. 2a,b	.226	.168	.126	1.35	2 - 15
figs. 3a,b	.201	.134	.101	1.51	2 - 2
fig. 4	.210	.118	.101	1.78	2 - 12
fig. 5	.168	.101	.101	1.66	2 - 2
fig. 6	.252	.151	.084	1.68	2 - 12
fig. 7	.235	.176	.101	1.34	2 - 22

Comparison and affinities.—*Amphitremoida huffmani* is similar to the type species of the genus, *A. citroniforma* Eisenack, 1937, in size and general shape, but it differs in lacking the wartlike apertural structures of *A. citroniforma.*

Type locality.—The holotype is from sample 21 of the Louisiana limestone at Locality 2, Louisiana, Missouri.

Stratigraphic occurrence.—*Amphitremoida huffmani* was found fairly commonly in the Louisiana limestone in nine samples from two localities. See Chart 1 for details of occurrence.

Remarks.—This species is named for Dr. William Huffman, Dean of the University College of the University of Louisville in recognition of his past help.

Amphitremoida? sp. Pl. 12, fig. 11

Description.—Test free, consisting of a single, originally somewhat inflated, elongate chamber with an aperture surrounded by a thickened lip at each end; test presently compressed; length/width ratio of two specimens is 2.4 and 2.8; test fractured at closely spaced intervals across its width probably due to compression; wall fairly thick and rather rough, composed of fine siliceous grains in siliceous cement; color of test, buff.

Measurements.—See Table 8 for measurements of *Amphitremoida?* sp.

Table 8. Measurements of figured specimen of *Amphitremoida?* sp., in mm.

Plate 12	length	diam.	diam. apert. ends	diam. apert.
fig. 11	.930	.386	.151-.168	.033, .033

Comparison and affinities.—The three present specimens are similar to some of the figured specimens of *Hippocrepinella biaperta* Crespin (1958, pp. 37, 38, pl. 1, figs. 4-8) from the Permian of Australia, but the present form is smaller, has a proportionately smaller aperture, and a thicker wall.

Stratigraphic occurrence.—Only three specimens of this form were found in the Louisiana limestone, in three samples from two localities. See Chart 1 for details of occurrence.

Family **SACCAMMINIDAE**

Genus **PSAMMOSPHAERA** Schultze, 1875

Psammosphaera? sp. A Pl. 12, figs. 39-41

Description.—Test free, spheroidal to inflated discoidal, of small to moderate size; no apertures noted; no protuberances on test; test wall thin to moderately thin, composed of fine to medium-grained quartz in siliceous cement; color of test, white to buff.

Measurements.—See Table 9 for measurements of figured specimens of *Psammosphaera?* sp. A, and Table 10 for range in measurements of this form.

Table 9. Measurements of *Psammosphaera?* sp. A, in mm.

Plate 12	max. diam.	min. diam.	thickness	locality and sample numbers
fig. 39	.226	.218	.126	4 - 1
fig. 40	.403	.302	.193	5 - 1
fig. 41	.510	.386	.269	2 - 20

Table 10. Range in measurements of five specimens of *Psammosphaera?* sp. A, in mm.

max. diam.	.185-.510
min. diam.	.160-.386
thickness	.126-.285

Comparison and affinities.—The true affinities of this form will not be known until a detailed analysis of the various species of *Psammosphaera* and related genera from the Lower Paleozoic (of several authors) has been completed. This problem will be considered in our paper on the Silurian and Devonian Foraminifera of Kentucky and southern Indiana.

Stratigraphic occurrence.—*Psammosphaera? sp.* A was found commonly in the Louisiana limestone in 30 samples from five localities. See Chart 1 for details of occurrence.

Psammosphaera? sp. B Pl. 12, figs. 28-33

Description.—Test subglobose to flattened discoidal in shape; medium to coarse-grained; outer surface generally rough with small amounts of light brown organic material between the quartz grains in some parts of most tests; siliceous cement abundant; color of test, white to gray to light brown to tan, depending upon the amount of residual organic material in the test.

Measurements.—See Table 11 for measurements of *Psammosphaera?* sp. B, and Table 12 for range in measurements of this form.

Table 11. Measurements of figured specimens of *Psammosphaera?* sp. B, in mm.

Plate 12	max. diam.	min. diam.	thickness	average size of grains	locality and sample numbers
fig. 28	.436	.386	.168	.02-.08	2 - 4
fig. 29	.335	.302	.235	.02-.04	1 - 3
fig. 30	.369	.335	.218	.02 or less	2 - 14
fig. 31	.470	.453	.294	.02-.05	1 - 3
fig. 32	.436	.411	.369	.02-.03	2 - 2
fig. 33	.604	.335	.218	.02-.03	2 - 6

Table 12. Range in measurements of 13 specimens of *Psammosphaera?* sp. B, in mm.

max. diam	.185-.692
min. diam.	.168-.554
thickness	.084-.369
av. size grains	.017-.08

Comparison and affinities.—This form somewhat resembles *Blastammina* Eisenack, 1932, particularly in a few specimens which have the flatter surfaces of the quartz grains parallel to the surface of the test and which display more residual organic material in the test wall than do other specimens of this form. There are excellently preserved and numerous specimens of *Blastammina* in the Hannibal shale of Missouri and western Illinois. Inasmuch as we are preparing a report on the Foraminifera of the Hannibal, we prefer to withhold formal specific designation of the present form until relationships of *Psammosphaera* and *Blastammina* can be fully investigated.

Stratigraphic occurrence.—*Psammosphaera*? sp. B was found in the Louisiana limestone in 11 samples from four localities. See Chart 1 for details of occurrence.

Psammosphaera? sp. C Pl. 12, figs. 34, 35

Description.—Test free, somewhat compressed, ellipsoidal; no apertures apparent; wall thin, composed of fine siliceous grains in siliceous cement; color of test, buff to white.

Measurements.—See Table 13 for measurements of *Psammosphaera*? sp. C.

Table 13. Measurements of figured specimens of *Psammosphaera*? sp. C, in mm.

Plate 12	max. diam.	min. diam.	thickness	locality and sample numbers
fig. 34	.218	.118	.084	2 - 13
fig. 35	.369	.185	.084	2 - 2

Comparison and affinities.—The exact affinities of this form are not known now. It resembles *Amphitremoida huffmani,* new species, but no apertures can be seen and the shape of the test is less regular.

Stratigraphic occurrence.—*Psammosphaera*? sp. C was found in the Louisiana limestone in two samples from one locality. See Chart 1 for details of occurrence.

Genus **THURAMMINA** Brady, 1879

Thurammina adamsi, new species Pl. 12, figs. 20-27

Description.—Test free, perhaps originally nearly spherical, but presently more or less collapsed and compressed, especially in larger specimens; apertures at ends of numerous small, pointed, irregularly spaced protuberances which vary in size and length and which appear to be partially broken off in some instances; protuberances appear to be more numerous along the edges of the compressed tests, but perhaps compression has flattened other protuberances lying in the direction of compression; test wall thin, composed of fairly fine siliceous grains in siliceous cement; color of test, buff to white.

Measurements.—See Table 14 for measurements of *Thurammina adamsi* and Table 15 for comparison with *T. echinata* Dunn, 1942, *T. subsphaerica* Moreman, 1930, and *T. pustulosa* Gutschick, Weiner, and Young, 1961.

Table 14. Measurements of figured specimens of *Thurammina adamsi,* in mm.

Plate 12	min. diam.	max. diam.	thickness	locality and sample numbers
fig. 20	.352	.436	.235	2 - 23
fig. 21	.260	.302	.101	2 - 22
fig. 22	.328	.386	.168	2 - 23
fig. 23	.352	.394	.218	2 - 11
fig. 24	.328	.369	.185	2 - 12
fig. 25	.386	.445	.118	4 - 1
fig. 26	.420	.453	.218	4 - 1
fig. 27	.428	.604	.218	

Table 15. Range in measurements of 13 specimens of *Thurammina adamsi* and comparison with *T. echinata, T. subsphaerica,* and *T. pustulosa,* in mm.

	T. adamsi	*T. echinata*	*T. subsphaerica*	*T. pustulosa*
min. diam.	.201-.420	-	-	.47-.60
max. diam.	.235-.470	.26, .30, .62	.84, 1.20	.58, .73
thickness	.101-.252	-	-	-
nature of apertures	small, pointed, irregularly spaced	pointed, tubular, almost covering surface	broad, nipple-like	short, uniform in size and shape

Comparison and affinities.—*Thurammina adamsi* resembles *T. echinata* Dunn (1942, p. 331, pl. 43, figs. 20, 21, 23) and the specimen which Ireland (1939, figs. A—27) identified as *T. echinata* on the basis of Dunn's unpublished material. In addition, *T. adamsi* is similar to *T. subsphaerica* Moreman (1930, p. 52, pl. 5, fig. 16). *T. adamsi* differs from *T. echinata* in having fewer and shorter protuberances, and differs from *T. subsphaerica* in having more pointed protuberances and in being much smaller.

Thurammina adamsi somewhat resembles *T. pustulosa* Gutschick, Weiner, and Young, 1961, but the projections on *T. pustulosa* are uniform in size and apparently are more abundant than those on *T. adamsi.*

Type locality.—The holotype is from the Louisiana limestone (sample 1) at Locality 4 at Hamburg, Illinois.

Stratigraphic occurrence.—*Thurammina adamsi* was found fairly commonly in the Louisiana limestone in six samples from two localities. See Chart 1 for details of occurrence.

Remarks.—*Thurammina adamsi* is named for Dr. Carl E. Adams, Chairman of the Natural Science Division of the University of Louisville, for his unfailing interest in and support of geological research at the University.

Thurammina strickleri, new species Pl. 12, figs. 16-19

Description.—Test free, small, nearly spherical to slightly polygonal, somewhat compressed; apertures tiny and round, generally clearly visible, at ends of short, rather regularly spaced, more or less prominent, nipple-like protuberances, six to 12 of which can be seen from one viewpoint; protuberances less clearly seen on more compressed tests; wall smooth, composed of fine siliceous grains in siliceous cement; color of test, white to buff.

Measurements.—See Table 16 for measurements of *Thurammina strickleri,* and Table 17 for comparison with *T. delicata* Ireland, 1939, *T. papillata* Brady (Moreman, 1930), and *T. hexagona* Dunn, 1942.

Table 16. Measurements of figured specimens of *Thurammina strickleri,* in mm.

Plate 12	min. diam.	max. diam.	thick-ness	no. of apertures seen from one viewpoint	locality and sample numbers
fig. 16	.260	.269	.195	12	3 - 1
fig. 17	.235	.252	.143	7	2 - 2
fig. 18	.277	.285	.143	11	2 - 2
fig. 19	.218	.252	.151	8?	2 - 2

Comparison and affinities.—*Thurammina strickleri* is similar in appearance to *T. delicata* Ireland (1939, p. 196, figs. A—28, 29) and to the form which Moreman (1930, p. 51, pl. 5, fig. 13) referred to *T. papillata* Brady, but which probably is another species, as Crespin (1958, p. 40) also noted. *T. strickleri* differs from *T. delicata* in having more prominent apertural protuberances and from Moreman's *T. papillata* Brady in having only about one-half as many protuberances and in being considerably smaller.

Thurammina hexagona Dunn (1942, p. 332, pl. 44, fig. 15) is somewhat similar to *T. strickleri,* but *T. hexagona* has fewer and more slender protuberances, is larger, and is apparently more coarse grained.

Type locality.—The holotype is from the lower one-foot-thick bed of the Louisiana limestone (sample 1) at Locality 3, Clarksville, Missouri.

Stratigraphic occurrence.—*Thurammina strickleri* occurs rather commonly in the seven samples from three localities in which it was found. See Chart 1 for details of occurrence.

Remarks.—This new species is named for Dr. Woodrow M. Strickler, Executive Vice-President of the University of Louisville, who has been generous in supporting our research.

Table 17. Range in measurements of 21 specimens of *Thurammina strickleri* and comparison with *T. delicata, T. papillata,* and *T. hexagona,* in mm.

	T. strickleri	*T. delicata*	*T. papillata*	*T. hexagona*
min. diam.	.172-.277	-	-	-
max. diam.	.185-.294	.200, .300	.840	.460, .510
thickness	.084-.195	-	-	-
no. of apertures seen from one viewpoint	6-12	6?, 9?	23	6?, 7?

Family **HYPERAMMINIDAE**

Genus **HYPERAMMINA** Brady, 1878, emend. Conkin, 1954

Hyperammina sappingtonensis Gutschick, 1962 Pl. 14, figs. 1-20

Hyperammina sappingtonensis Gutschick, 1962, Jour. Paleont., vol. 36, No. 6, pp. 1298, 1299, pl. 174, figs. 1-17; pl. 175, figs. 16, 18; text-figs. 3A-H.

Description.—Dimorphism exhibited with easily recognizable megalospheric and microspheric forms; megalospheric form has a distinct, small, spherical to subspherical proloculus followed by a gradually enlarging elongate second chamber; test slightly to strongly constricted at irregular intervals; apertural lip present in some specimens; aperture slightly constricted; color of test white to cream to buff; test composed of fine siliceous grains in siliceous cement.

Microspheric form longer and larger than megalospheric form, the test forming a sharply pointed extremely elongate cone; proloculus small and pointed; second chamber expands gradually for about half its length, thereafter expanding even more gradually; test curved, particularly in the initial portion of some specimens; aperture and composition and color of test as in megalospheric form.

Measurements.—See Table 18 for measurements of megalospheric and microspheric forms of *Hyperammina sappingtonensis* from the Louisiana limestone, and Table 19 for comparison with the original types from the Sappington formation and with *H. nitida* Gutschick and Treckman, 1959, *H. constricta* Gutschick and Treckman, 1959, and *H. kahlleitensis* Blumenstengel, 1961.

Table 18. Measurements of figured specimens of *Hyperammina sappingtonensis*, in mm.

Plate 14	length	diam. proloc.	diam. tube max.	diam. tube min.	diam. apert.	form	locality and sample numbers
fig. 1	.897	-	.134	.033	.075	micro.	2 - 2
fig. 2	.830	-	.101	.015	-	"	2 - 5
fig. 3	.814	-	.067	.015	-	"	2 - 2
fig. 4	.800	.015	.101	.015	-	"	2 - 2
fig. 5	1.445	-	.084	.017	-	"	2 - 2
fig. 6	.727	.025	.118	.025	-	"	2 - 2
fig. 7	.665	.010	.087	.010	.050	"	2 - 2
fig. 8	.738	.020	.095	.020	-	"	3 - 1
fig. 9	1.125	.015	.075	.015	-	"	2 - 2
fig. 10	1.417	-	.084	.025	-	"	2 - 2
fig. 11	.487	.042	.084	.033	.033	meg.	2 - 2
fig. 12	.520	.050	.067	.038	.033	"	2 - 2
fig. 13	.302	.054	.067	.038	.033	"	2 - 2
fig. 14	.478	.067	.071	.042	.033	"	2 - 2
fig. 15	.714	.046	.067	.029	-	"	2 - 2
fig. 16	.586	.050	.075	.029	-	"	3 - 1
fig. 17	.487	.050	.084	.029	.042	"	2 - 2
fig. 18	.586	.059	.067	.038	.025	"	2 - 2
fig. 19	.860	.058	.101	.030	.050	"	3 - 1
fig. 20	.797	.050	.092	.033	-	"	3 - 1

Comparison and affinities.—The specimens of *Hyperammina sappingtonensis* from the Louisiana limestone are identical with the original types from the Sappington formation of Montana, except the Louisiana produced several longer microspheric forms.

Hyperammina sappingtonensis is similar to *H. constricta* Gutschick and Treckman, 1959 in having an elongate, slender, tapering test; however the constrictions in *H. sappingtonensis* are not regular nor are they pronounced as in *H. constricta*. The proloculus of *H. constricta* has not been observed.

Table 19. Range in measurements of 12 microspheric and 19 megalospheric specimens of *Hyperammina sappingtonensis* and comparison with the original types, with *H. nitida, H. constricta,* and *H. kahlleitensis.*

	length		max. diam.		diam. proloc.	
	micro.	megalo.	micro.	megalo.	micro.	megalo.
H. sappingtonensis	up to 1.445	up to .860	.067-.134	.067-.101	.010-.025	.038-.070
original types	.850	up to 1.07	.085	.080-.153	.023	.025-.060
H. nitida	.800-.990		.120-.150		.030-.045	
H. constricta	up to 2.200		.090-.110		-	
H. kahlleitensis	1.120-3.540		.140-.220		.080-.180	

Hyperammina sappingtonensis is also similar to *H. nitida* Gutschick and Treckman, 1959, but *H. sappingtonensis* differs in having a more constricted and proportionally more slender test and a microspheric form with a pointed, dartlike test.

Blumenstengel (1961) described a form from the Upper Devonian of Germany, *Hyperammina kahlleitensis,* which appears to be identical with *H. sappingtonensis;* however, there is a marked discrepancy between the stated measurements and the figured specimens of *H. kahlleitensis.* We have attempted to learn the answer to this problem but have been unsuccessful at this date. From the stated measurements, the smallest specimens of *H. kahlleitensis* are larger than the largest specimens of *H. sappingtonensis* (this difference in size could be due to environmental control or even perhaps to the subtleties of subspeciation as viewed only dimly through the expanse of time). In any event, the figures of *H. kahlleitensis* are stated to be at X 50 and as such would seem to be identical with *H. sappingtonensis,* but from the measurements given, the figures seem to be at about X 25. Until this matter is cleared up we refer our specimens to *H. sappingtonensis* rather than to consider this species a junior subjective synonym of *H. kahlleitensis* Blumenstengel, 1961.

Stratigraphic occurrence.—*Hyperammina sappingtonensis* was originally described from the lower Sappington formation of Montana. We have, in addition, found *H. sappingtonensis* in the Kinderhookian McCraney limestone at Seehorn Creek, Illinois. *H. sappingtonensis* occurs abundantly in the Louisiana limestone and was found in 33 samples from five localities. See Chart 1 for details of occurrence.

Family **REOPHACIDAE**

Genus **ASCHEMONELLA** Brady, 1879

Aschemonella louisiana, new species Pl. 13, figs. 1-6

Description.—Test free, consisting of from one to four chambers (in present specimens) ; chambers generally sausage-shaped or lobe-shaped and inflated, with a small simple aperture at end of chamber; chambers apparently added in a budlike fashion, with no set arrangement, although some are uniserially arranged; chambers connected by a short to long, fairly broad, stoloniferous neck which merges with the inflated chambers; some broken specimens consist of an inflated lobe-shaped chamber with a small aperture at one end and a larger opening at the opposite end where the neck between chambers was broken off; one specimen consists of an elongate, sausage-shaped chamber which is constricted in the middle (may be considered as two chambers) with a simple small aperture at one end and a small aperture with a short, tapering, slender neck at the other end; apertures not visible on a few specimens, but readily seen, though small, on most specimens, one aperture at each extremity of the test; wall thin, composed of fine siliceous grains in siliceous cement; color of test, white, with ferruginous staining on some tests.

Measurements.—See Table 20 for measurements of *Aschemonella louisiana,* and Table 21 for range in measurements.

Table 20. Measurements of figured specimens of *Aschemonella louisiana,* in mm.

Plate 13	length	diam. chambers	diam. necks	diam. apert.	locality & sample nos.
fig. 1	.487	.244, .201	.185	.017	2 - 2
fig. 2	.369	.168, .143	.118	-	3 - 1
fig. 3	.403	.168	.046	.025	2 - 2
fig. 4	.675X .460	.118, .126, .151, .252	.075, .118, .126	.020, .025	3 - 1
fig. 5	.487	.138, .134	.105	.025, .017	3 - 1
fig. 6	.745	.218, .218	.151, .059	.025	2 - 2

Table 21. Range in measurements of nine specimens of *Aschemonella louisiana,* in mm.

length of test	.352-.780
diam. of chambers	.118-.285
diam. of necks	.046-.185
diam. of apertures	.017-.025

Comparison and affinities.—The assignment of these specimens to

Aschemonella was made with some difficulty. The type description by Brady (1879, p. 44) is worth quoting in this connection inasmuch as it makes the nature of *Aschemonella* more understandable.

> Test free, consisting of one or more chambers of irregular size and shape. Chambers inflated, often with more than two tubulated apertures, any of which may produce a fresh segment. Walls thin, compactly built; exterior slightly rough, sometimes acerose with partially embedded sponge-spicules. Segments variable in size; length ⅛ inch (3 millim), more or less. This is a type the nature and affinity of which it is very difficult to comprehend. The form and size of segments might almost seem to be a matter of accident, and yet when a number are seen together they bear a quite unmistakable general resemblance to each other, not only in shell-texture and substance, but in their habit of growth. It is impossible to describe the multiplicity of forms the chambers assume. Sometimes they are elongate, straight or curved, with rounded or tapering ends, either unconstricted or constricted at intervals, as though tied up crookedly. More commonly, instead of the two terminal apertures, that the chambers of the polythalmus Foraminifera usually present, the lobes have three or four, or even five, tubulations, any one of which may give rise to a new segment, for which it forms the stoloniferous passage. Very often the segments are forked, and each branch terminates in an aperture. A large proportion of the specimens have only one chamber, but probably this is in part due to fracture, the connecting tubes being narrow and slender in proportion to the weight of the lobes, but many have two, and occasional examples have been found with three segments. In point of size the variation is equally marked; the individual segments vary from very small dimensions up to one-fifth of an inch or even more in length.

The present specimens of *Aschemonella louisiana* vary among themselves in shape and size, but all conform to a general pattern of having one or more inflated sausage-shaped or lobe-shaped chambers with a small simple aperture at the end of each chamber; multiple chambers are joined by a broad stoloniferous neck.

Aschemonella louisiana is somewhat similar to the type species of *Aschemonella, A. catenata* (Norman), 1876 (Brady, 1884, pl. 27, figs. 1-11), but *A. louisiana* differs in having broader necks between chambers, in usually lacking apertural necks at the extremities of the test, in being smaller, and in having fewer apertures on any one chamber. However, the central chamber of the specimen of *A. louisiana* in figure 4, Plate 13 evidently had three apertures before the three additional chambers "budded" from it.

Workman and Gillette (1956) reported *Aschemonella*? from the Louisiana limestone. We believe their reference was to the numerous specimens of *Oxinoxis* inasmuch as *Aschemonella* is rare in the Louisiana, and specimens of *O. ligula* are seen in some abundance in nearly every sample of the Louisiana which we have examined.

Forms which are somewhat similar to *Aschemonella* have been described and referred to other genera (*Croneisella* Dunn, 1942; *Gastroammina* Dunn, 1942; *Shidelerella* Dunn, 1942; and *Ordovicina* Eisenack, 1937) ; the relationship between these forms is not known, but there seems to be some kinship.

Type locality.—The holotype is from the lower one-foot-thick bed of the Louisiana limestone (sample 1) at Locality 3, Clarksville, Missouri.

Stratigraphic occurrence.—The genus *Aschemonella* was reported by Cushman (1948, p. 90) to range from the Cretaceous to Recent, with similar forms which may belong in *Aschemonella* extending back as far as the Silurian. This new species is the first Paleozoic species known to us which is described under the generic name *Aschemonella.* We have not yet recognized this form in any other Devonian or Mississippian formation. *A. louisiana* was found in two samples from the lower part of the Louisiana limestone at two localities. See Chart 1 for details of occurrence.

Genus **OXINOXIS** Gutschick, 1962, emend.

Oxinoxis Gutschick, 1962, Jour. Paleont., vol. 36, No. 6, pp. 1299, 1300, pl. 174, figs. 25, 26; pl. 175, figs. 1-8, 12, 14; text-figs. 4A, B.

Saccammina Gutschick, Weiner, and Young, 1961, Jour. Paleont., vol. 35, No. 6, p. 1207, pl. 150, figs. 3, 6, 8, 11; text-figs. 3—14, 18-22; Gutschick, 1962, Jour. Paleont., vol. 36, No. 6, p. 1297, text-fig. 2A-C.

Type species, *Oxinoxis ligula* (Gutschick, Weiner, and Young), 1961 =*Oxinoxis botrys* Gutschick, 1962 (monotypic genus).

Gutschick (1962) erected *Oxinoxis* for multilocular, attached, uniserial, arenaceous tests, with *O. botrys* Gutschick, 1962 as the type species. In 1961 Gutschick, Weiner, and Young described a unilocular attached form, "*Saccammina*" *ligula,* which we believe represents only one chamber of the multilocular form *O. "botrys".* The multilocular forms are comparatively less frequently found in their entirety as the chambers are in many instances broken apart at the neck which joins them. We are unable to distinguish the unilocular *"S." ligula* from one chamber of the multilocular *O. "botrys".* We consider *"S." ligula* to be the type species of the monotypic genus *Oxinoxis,* and *O. botrys* to be a junior subjective synonym of *O. ligula.* Gutschick (personal communication, April, 1963) would agree with this interpretation.

Our emended description of *Oxinoxis* follows: test consists of from one to several chambers which are attached to a greater or lesser degree;

chambers range from hemispherical or hemipyriform to nearly spherical or nearly pyriform in shape, with a tubular or hemitubular apertural neck; chambers of multilocular tests are joined by overlapping the preceding chamber partially or by overlapping the apertural neck entirely or partially to form an irregular to regular uniserial series; chambers enlarge progressively; attachment of the test takes place variously, being seen on the same side of all chambers in some tests, on various sides of the chambers in other tests, and in some chambers but not in other chambers in still other tests; in a few instances the test appears to be nearly free; the object of attachment served as the wall of the test along the surface of attachment; apertural neck may have a lip; wall arenaceous, composed of siliceous grains in siliceous cement; wall of test not entirely solid in most specimens, so that there are irregularly shaped holes in the wall; a few specimens have been seen which are filled with secondary ferruginous material which bulges out through these holes in such a way as to indicate that originally a flexible chitinous lining covered the protoplasm, with the siliceous material of the test enclosing the softer parts like a net; indeed, a few tests are seen to possess a chitinous lining.

Oxinoxis has certain characteristics in common with several other genera (*e. g. Aschemonella, Saccammina, Hormosina,* and *Reophax*), as indicated by Gutschick (1962, p. 1300), but *Oxinoxis* differs from all in being an attached form. In addition, *Oxinoxis* is similar to some species of *Placopsilina,* such as *P. redoakensis* (Galloway and Harlton), 1928 and *P. ciscoensis* Cushman and Waters, 1930, from the Pennsylvanian of Oklahoma and Texas, in being an attached, uniseral form. Barnard (1958, pp. 117, 118) discussed some Mesozoic adherent Foraminifera, including the arenaceous, attached, polythalmus *Placopsilina,* and indicated that two forms are found within that genus:

> . . . one having an initial coiled stage followed by an uncoiled portion . . . and the other having no initial coil. In the former the chambers in later stages of the test abut directly against one another, with no well-marked constriction along the septa, whereas in the latter the chambers tend to be hemispherical, with constricted necks connecting them . . . . The problem arises as to what d'Orbigny's original specimens [of *Placopsilina cenomana,* the type species, which were unfigured] looked like. Both Reuss and Chapman figure *Pl. cenomana* d'Orbigny as having a well-marked initial coil, and if these figures are a correct interpretation of d'Orbigny's specimen, then the material from the Jurassic, having hemispherical chambers, should be assigned to a different genus. However, the present author thinks that it is undesirable to take this step until more evidence is available.

It seems that the specimens of *Placopsilina* which Barnard mentioned as perhaps needing assignment to a different genus might well fit in *Oxinoxis*.

Oxinoxis ligula (Gutschick, Weiner, and Young), 1961 emend.
Pl. 15, figs. 1-31

Saccammina ligula Gutschick, Weiner, and Young, 1961, Jour. Paleont., vol. 35, No. 6, p. 1207, pl. 150, figs. 3, 6, 8, 11; text-figs. 3—14, 18-22; Gutschick, 1962, Jour. Paleont., vol. 36, No. 6, p. 1297, text-fig. 2A-C.

Oxinoxis botrys Gutschick, 1962, Jour. Paleont., vol. 36, No. 6, pp. 1300, 1301, pl. 174, figs. 25, 26; pl. 175, figs. 1-8, 12, 14; text-figs. 4A, B.

Description.—Test consists of from one to five (perhaps more), more or less attached chambers, generally hemispherical to hemipyriform in shape, with a slender to fairly broad apertural neck on each chamber; chambers joined by overlapping of preceding chamber partially or by overlapping the neck of preceding chamber entirely or partially; tests display great variety in the nature of the wall, shape of the chambers, arrangement of the chambers, and amount and position of attachment; unilocular tests vary in shape from a nearly free and complete, spherical to pyriform chamber with a slender to rather stocky tubular neck (producing an overall shape resembling a light bulb) to a sievelike or netlike roughly hemispherical or hemipyriform chamber showing attachment in one or more places and with a hemitubular or tubular apertural neck; multilocular tests also vary in shape from forms composed of nearly free and complete, spherical to pyriform chambers which progressively increase in size and are arranged in a rectilinear series and are joined by tubular necks, to forms composed of sievelike chambers of roughly hemispherical or hemipyriform shape which increase in size and show attachment in various places and which are joined at various places by necks which are visible or invisible externally depending on how closely the chambers are joined, forming an irregular to regular uniserial series; in general, the tests having the greater amount of attachment are more irregular in the arrangement of the chambers, probably because they were attached to a more or less irregular surface; chambers were added to the preceding chamber at angles varying up to as much as 180°; many tests of both unilocular and multilocular forms show attachment on only one side so that the chambers are in general hemipyriform or hemispherical, but this is not a constant characteristic; some tests show attachment in some chambers, but not in others, and not necessarily in the early portion of the test; an attached chamber does not necessarily have a hemitubular attached neck, nor does an unattached chamber necessarily have a tubular neck; the object of attachment apparently served as the wall of the test along the surface of attachment; wall composed of fine to moderately coarse siliceous grains in siliceous cement; most tests have holes of various rounded shapes in the wall where an inner chitinous lining bulged through as indicated by the ferruginous filling in some tests (Pl. 15, fig. 14) which bulges through the holes and by the actual chitinous lining being seen in a few tests; tiny slits in some tests seem to indicate that these particular tests incorporated slender calcareous spicules in the wall, or that these tests were attached in part to slender objects, or to slender portions of the larger object of attachment; color of test, white to buff to gray.

Measurements.—See Table 22 for measurements of *Oxinoxis ligula* from the Louisiana limestone and Table 23 for comparison with forms from the Sappington formation of Montana (Gutschick, 1962) and the Welden and Chappel limestones (Gutschick, Weiner, and Young, 1961).

Comparison and affinities.—We are unable to distinguish the unilocular *"Saccammina" ligula* as described and figured by Gutschick, Weiner, and Young (1961) and Gutschick (1962), and our unilocular specimens from the Louisiana limestone from single chambers of the multilocular *Oxinoxis "botrys"* as described and figured by Gutschick (1962), and our multilocular specimens from the Louisiana limestone. Gutschick (1962, p. 1295) reported both species from the Louisiana limestone. We have recently (April, 1963) discussed this matter with Gutschick, and he would agree that the unilocular and multilocular forms probably belong in the same species; thus, we place both forms in *Oxinoxis ligula,* having demonstrated the wide range of variation in *O. ligula.*

Oxinoxis ligula vaguely resembles *Sorosphaera adherens* Crespin, 1961 and *Colonammina imparilis* Crespin, 1961, both from the Upper Devonian of Western Australia. However, the chambers of *S. adherens* are not connected by a neck and are not always in a uniserial arrangement. *C. imparilis* resembles unilocular forms of *O. ligula,* but differs markedly in having a chitinous apertural neck. Neither of the Australian forms has holes in the test wall as do most specimens of *O. ligula.*

Stratigraphic occurrence.—Gutschick, Weiner, and Young (1961, p. 1207) reported unilocular forms of *Oxinoxis ligula* from the Kinderhookian Welden limestone of Oklahoma, the Osagian portion of the Chappel limestone of Texas, and the "upper Rockford shale" of southern Indiana. Gutschick (1962) reported both unilocular and multilocular forms from the lower Sappington formation of Montana. In addition,

Table 22. Measurements of figured specimens of *Oxinoxis ligula,* in mm.

Plate 15	length test	diam. chamber	length chamber	diam. neck	length neck	no. of chambers	locality and sample nos.
fig. 1	.201	.151	.185	.042	-	1	2 - 2
fig. 2	.244	.201	.244	.067	-	1	2 - 2
fig. 3	.252	.185	.201	.050	-	1	2 - 2
fig. 4	.235	.185	.185	.067	.042	1	2 - 2
fig. 5	.285	.176	.201	.042	.067	1	2 - 15
fig. 6	.252	.134	.193	.025	.050	1	2 - 2
fig. 7	.487	.285	.302	.101	.185	1	2 - 16
fig. 8	.330	.201	.262	.067	.050	1	2 - 2
fig. 9	.335	.226	.235	.101	.101	1	2 - 22
fig. 10	.277	.218	.201	.067	.092	1	2 - 2
fig. 11	.490	.394	.319	.126	.168	1	2 - 24
fig. 12	.185	.126	.143	.050	.042	1	2 - 2
fig. 13	.386	.302	.344	.075	-	1	2 - 2
fig. 14	.436	.302	.335	.101	.110	2	2 - 2
		.193	.218	-	-		
fig. 15	.521	.453	.453	-	-	1	2 - 21
fig. 16	.503	.252	.260	.084	.092	2	2 - 24
		.319	.285	.101	.168		
fig. 17	.436	.277	.260	.151	.151	1	2 - 14
fig. 18	.640	.244	.269	.118	.185	3	1 - 1
		.218	.201	.118	-		
		.176	.134	-	-		
fig. 19	.604	.386	.369	.168	.235	1	1 - 2
fig. 20	.762	.277	.319	.092	.168	3	2 - 15
		.193	.201	-	-		
		.176	.134	-	-		
fig. 21	.857	.453	.436	.134	.218	2	2 - 3
		.269	.260	-	-		
fig. 22	.906	.302	.302	.143	-	4	1 - 1
		.302	.185	-	-		
		.269	.185	-	-		
		.269	.218	.168	-		
fig. 23	.780	.310	.252	.126	.168	2	1 - 1
		.226	.252	.118	.084		
fig. 24	.974	.403	.420	.151	-	4	1 - 5
		.285	.235	-	-		
		.235	.151	-	-		
		.134	.101	-	-		
fig. 25	.762	.436	.420	.201	.369	1	2 - 2
fig. 26	.840	.302	.302	.109	.302	2	2 - 18
		.185	.201	.084	.235		
fig. 27	.503	.360	.352	.118	.151	1	2 - 24
fig. 28	1.125	.360	.352	.126	.252	3	2 - 26
		.285	.285	.151	-		
		.235	-	.101	-		
fig. 29	.875	.570	.675	.235	.185	1	5 - 1
fig. 30	1.231	.394	.420	.176	.386	3	1 - 1
		.403	.335	.143	.134		
fig. 31	1.125	.352	.369	.118	.201	3	1 - 1
		.269	.285	.134	.101		
		.185	.168	.101	.084		

Table 23. Range in measurements of over 300 specimens of *Oxinoxis ligula* and comparison with previously described specimens, in mm.

	Oxinoxis ligula Louisiana ls.	Gutschick, Weiner, and Young (1961) and Gutschick (1962)	
		Oxinoxis "botrys"	*"Saccammina" ligula*
length of test	.168-1.231	.950-1.500	.380-.460
diam. of chamber	.092-.570	.150-.750	.250-.340
length of chamber	.118-.675	.270-.800	-
diam. of neck	.033-.235	.060-.220	.080-.090
length of neck	.033-.470	.060-.250	-

we have found *O. ligula* in the Middle Devonian Sellersburg limestone (Silver Creek and Beechwood members) of southern Indiana and Kentucky, in the Kinderhookian McCraney limestone at Burlington, Iowa, and Seehorn Creek, Illinois, and in the Chouteau limestone at Jonesboro, Illinois.

We find unilocular and multilocular forms of *Oxinoxis ligula* to be abundant in the Louisiana limestone of Missouri and Illinois; in a few samples there are many tiny unilocular forms along with fewer multilocular forms. We believe that further study would reveal multilocular forms in those formations from which thus far only unilocular forms have been reported.

Oxinoxis ligula was found in 32 samples of the Louisiana limestone from five localities. See Chart 1 for details of occurrence.

Remarks.—We found several small unilocular specimens in the Louisiana limestone (Plate 15, figs. 1-4, 8, 13) which have solid-walled tests and are apparently unattached, and which resemble *Proteonina cumberlandiae* Conkin, 1961, a Mississippian species. However, since some chambers of *Oxinoxis ligula* are found to be free and lack holes in the walls, we prefer to assign these above-mentioned few specimens to *O. ligula.*

Gutschick, Weiner, and Young (1961) and Gutschick (1962) suggested the possibility that the holes in the test wall of *Oxinoxis ligula* were due to the solution during acidization of calcareous fragments which had been incorporated in the wall. We were rather inclined to agree with this interpretation until we discovered specimens with ferruginous filling which bulges out through the holes, indicating that the chitinous lining bulged through the holes in the wall originally, with the siliceous test serving as a net to hold the animal to the object of attachment.

Family **AMMODISCIDAE**

Genus **AMMODISCUS** Reuss, 1862

Ammodiscus longexsertus (Gutschick and Treckman), 1959 Pl. 14, figs. 28-36

Involutina longexsertus Gutschick and Treckman, 1959, Jour. Paleont., vol. 33, No. 2, pp. 241, 242, pl. 35, figs. 10-14; Gutschick, 1962, Jour. Paleont., vol. 36, No. 6, p. 1301, pl. 174, figs. 28, 29; text-figs. 5A, B.

Involutina longexserta Gutschick and Treckman, 1959, Conkin, 1961, Bull. Amer. Paleont., vol. 43, No. 196, pp. 288-290, pl. 22, figs. 7, 9; pl. 26, fig. 18; fig. 22.

Lituotuba? sp., Gutschick, 1962, Jour. Paleont., vol. 36, No. 6, pp. 1301, 1302, pl. 174, fig. 30; text-fig. 6.

Description.—Test regularly to irregularly planispiral, becoming uncoiled; coiled portion circular to elliptical; second chamber expands gradually from a delicate inner portion and is coiled for from two to six whorls before uncoiling at more or less a right angle to the preceding whorls and in the same plane; length of uncoiled portion of the second chamber in unbroken tests is greater than the diameter of the coiled portion; coiling somewhat irregular in many specimens perhaps due to secondary distortion; extended portion may be distorted, probably secondarily, and may overlap previous portion of test or extend in an irregular fashion; delicate innermost portion of whorls missing in some specimens; tests vary considerably in size; tubular chamber is smooth in some specimens but irregularly constricted in others, perhaps secondarily; aperture circular, at open end of tubular second chamber; wall composed of fine siliceous grains in a moderate amount of siliceous cement; color of test, white to buff.

Measurements.—See Table 24 for measurements of *Ammodiscus longexsertus*, and Table 25 for comparison with the original types, with forms described by Conkin (1961), and with specimens from the Sappington formation (Gutschick, 1962).

Table 24. Measurements of figured specimens of *Ammodiscus longexsertus*, in mm.

Plate 14	diam. coiled portion	length test	max. diam. tube	no. of whorls	locality and sample numbers
fig. 28	.193	.310	.042	4	2 - 2
fig. 29	.188	.269	.050	3	2 - 2
fig. 30	.260	.352	.058	4?	5 - 2
fig. 31	.530	.685	.134	?	5 - 2
fig. 32	.319	.727	.075	5	1 - 4
fig. 33	.189	.538	.050	3	2 - 2
fig. 34	.210	.554	.067	4	2 - 2
fig. 35	.302	.638	.067	5½	2 - 2
fig. 36	.490	.762	.134	5	2 - 17

Table 25. Range in measurements of 19 specimens of *Ammodiscus longexsertus,* and comparison with the original types, with specimens from the Sappington formation, and with specimens described by Conkin (1961).

	diam. coiled part	length test	max. diam. tube	no. of whorls
A. longexsertus	.160-.530	.252-.974	.042-.134	2-6
original types	.210-.270	.500-.910	.060-.070	"several"
Sappington	"generally slightly smaller than" original types			
Conkin, 1961	.269-.470	.394-.899	-	2-3 plus

Comparison and affinities.—The present specimens compare well with the previously described specimens of the species.

Gutschick (1962) identified some specimens from the lower Sappington formation as *Lituotuba?* sp. and reported *Lituotuba* from the Louisiana limestone. In view of the numerous distorted specimens in the Louisiana limestone, which are identical with undistorted specimens of *Ammodiscus longexsertus* in every other respect, we believe, as Gutschick (1962, p. 1301) suspected in regard to the Sappington specimens, that the specimens showing irregularity in coiling do not belong in *Lituotuba* but rather are irregular forms of *A. longexsertus.*

Stratigraphic occurrence.—Ammodiscus longexsertus is known from the lower Sappington formation (Gutschick, 1962) and from the Lower Mississippian Sanderson formation, Eulie shale, Bedford shale, Sunbury shale, and lower New Providence formation (Conkin, 1961). The report of the species from the Upper Devonian New Albany formation (Conkin, 1961, p. 289) seems to be in error (the species was found in the Kinderhookian Sanderson member of the New Albany formation).

We have, in addition, found *Ammodiscus longexsertus* in the McCraney limestone at Seehorn Creek, Illinois, and at Burlington, Iowa.

Ammodiscus longexsertus was found abundantly in the Louisiana limestone, in 35 samples from five localities. See Chart 1 for details of occurrence.

Genus **TOLYPAMMINA** Rhumbler, 1895

Tolypammina bulbosa (Gutschick and Treckman), 1959, emend.

Pl. 13, figs. 12-17

Ammovertella bulbosa Gutschick and Treckman, 1959, Jour. Paleont., vol. 33, No. 2, p. 247, pl. 37, figs. 4, 5, 8, 9; Gutschick, Weiner, and Young, 1961, Jour. Paleont., vol. 35, No. 6, p. 1218, pl. 150, fig. 4.

Tolypammina sp. A Gutschick and Treckman, 1959, Jour. Paleont., vol. 33, No. 2, p. 247, pl. 37, figs. 6, 7.

Tolypammina sp. B Gutschick and Treckman, 1959, Jour. Paleont., vol. 33, No. 2, p. 247, pl. 37, fig. 11.

Tolypammina continuus Gutschick, 1962, Jour. Paleont., vol. 36, No. 6, p. 1302, pl. 174, fig. 24; pl. 175, figs. 15, 17, 19, 21.

Description.—Test consists of a prominent spherical free proloculus and a long, irregularly winding, more or less attached second chamber which is tubular where free and hemitubular where attached; no two tests exhibit identical patterns of winding of the second chamber, but the tube does not in any instance wind planispirally around the proloculus, rather it extends a short to long distance from the proloculus before winding; winding may assume a variety of haphazard forms; attachment apparently took place in varying amounts, ranging from at only a few places along the length of the second chamber to along the entire preserved length of the second chamber; the test apparently was attached to objects of varying shape, from plane to highly irregular; in all cases the tube winds in a tolypamminid fashion, that is the winding is haphazard and rather loose so that the tube does not meander adjacent to itself to become a compact unit as does the test in ammovertellids (Conkin, 1961, pp. 299, 300) ; wall of test composed of fine to moderately coarse siliceous grains in a moderate amount of siliceous cement; color of test, white to buff to gray.

Measurements.—See Table 26 for measurements of *Tolypammina bulbosa* from the Louisiana limestone, and Table 27 for comparison with the forms which we place in synonymy with *T. bulbosa.*

Table 26. Measurements of figured specimens of *Tolypammina bulbosa,* in mm.

Plate 13	diam. proloc.	length test	diam. tube max.	diam. tube min.	locality and sample numbers
fig. 12	.151	-	.118	.075	1 - 1
fig. 13	.118	.335	.134	.084	2 - 2
fig. 14	.118	.875	.168	.101	5 - 3
fig. 15	.157	.604	.151	.084	1 - 1
fig. 16	.134	.604	.185	.084	1 - 1
fig. 17	.160	.586	.151	.101	5 - 1

Table 27. Range in measurements of eight specimens of *Tolypammina bulbosa* and comparison with "*Ammovertella*" *bulbosa* and *T.* sp. B from the Rockford limestone, and with *T. continuus* from the Rockford and Sappington formations.

	T. bulbosa	"*A.*" *bulbosa*	*T.* sp. B	*T. continuus*
diam. proloc.	.118-.160	.143-.300	.160-.180	.193-.275
min. diam. tube	.075-.101	.084-.140	.070-.101	.090-.140
max. diam tube	.118-.185	.134-.340	.170	.201-.300
length test	.335-.875 (broken)	.554-2.00	.814-1.20	.680-4.00

Comparison and affinities.—Gutschick and Treckman (1959, p. 247) described three forms which they named *Ammovertella bulbosa,* with a free spherical proloculus and an attached winding hemitubular second chamber, *Tolypammina* sp. A, also with a free spherical proloculus and a winding second chamber attached "by a very small area," and *T.* sp. B, with a large free spherical proloculus and a loosely spiralled attached tubular second chamber. Paratypes of these three forms in our possession as well as the published figures, indicate that the amount of attachment and pattern of winding varies considerably in all, so that one cannot be differentitiated from another in practice. Gutschick (1962, p. 1302) referred *T.* sp. A to a new species, *T. continuus,* and reported the species from the Louisiana limestone. However, based on all specimens available to us and on the figures of *T.* (*"Ammovertella"*) *bulbosa, T.* sp. A and B, and *T. continuus*, we believe all these forms should be placed in synonymy. Gutschick (personal communication, April, 1963) would agree with this.

Tolypammina bulbosa resembles *T. nexuosa* from the Upper Devonian of Australia (Crespin, 1961) but differs especially in having a much more prominent spherical proloculus.

The present specimens from the Louisiana limestone are on the whole slightly smaller in the diameter of the proloculus than some of the previously described forms, but their measurements fall within the range of published measurements and within the range of measurements of original types of *Tolypammina bulbosa* in our possession.

Tolypammina bulbosa is similar to *T. cyclops* Gutschick and Treckman, 1959, in possessing a prominent spherical proloculus, but the attached second chamber in *T. cyclops* makes one planispiral whorl about the proloculus before extending and winding in an irregular fashion, while the second chamber of *T. bulbosa* does not wind planispirally around the proloculus.

Tolypammina bulbosa is similar to *T. jacobschapelensis* in the nature of the second chamber, but the two species differ in that the proloculus of *T. jacobschapelensis* is attached and is a pointed egg- or heart-shape, while that of *T. bulbosa* is free and spherical.

Stratigraphic occurrence.—*Tolypammina bulbosa* is known from the lower Sappington formation of Montana and in the Lower Mississippian from the Rockford limestone of Indiana (Gutschick, 1962), Chappel limestone of Texas, Welden limestone of Oklahoma (Gutschick, Weiner, and Young, 1961), and uppermost Chattanooga shale of southwestern Missouri

(Conkin and Conkin, 1964). In addition, we have found this species in the McCraney limestone at Seehorn Creek, Illinois.

Tolypammina bulbosa was found sparingly in the Louisiana limestone, in three samples from three localities. See Chart 1 for details of occurrence.

Tolypammina cyclops Gutschick and Treckman, 1959 Pl. 13, fig. 11

Tolypammina cyclops Gutschick and Treckman, 1959, Jour. Paleont., vol. 33, No. 2, pp. 245, 246, pl. 36, figs. 1, 2, 4, 6, 7, 10-14; Conkin, 1961, Bull. Amer. Paleont., vol. 43, No. 196, pp. 301-303, pl. 22, figs. 14, 15; pl. 27, fig. 3; fig. 25; Gutschick, Weiner, and Young, 1961, Jour. Paleont., vol. 35, No. 6, p. 1217, pl. 150, figs. 5, 7, 9, 10; text-figs. 3—15, 16; Gutschick, 1962, Jour. Paleont., vol. 36, No. 6, pp. 1302, 1303, pl. 174, fig. 27; pl. 175, figs. 9-10, 22, 24.

Description.—Test consists of a free spherical proloculus and an attached hemitubular to tubular second chamber which winds for one planispiral whorl and then extends in an irregular manner; proloculus is raised above the level of the planispiral whorl; wall moderately coarse-grained, of siliceous grains in siliceous cement; color of test, white.

Measurements.—See Table 28 for measurements of *Tolypammina cyclops* and for comparison with the original types.

Table 28. Measurements of *Tolypammina cyclops,* in mm. and comparison with the original types.

Plate 13	length test	diam. proloc.	diam. whorl	diam. tube max.	diam. tube min.	locality and sample numbers
fig. 11	.537	.105	.252	.151	.058	2 - 2
original	up to	.075-	.150-	.060-	-	
types	2.00	.150	.260	.200	-	

Comparison and affinities.—This single specimen compares perfectly with the original types of *Tolypammina cyclops.*

Tolypammina cyclops is similar to *T. bulbosa* except that the second chamber of *T. cyclops* makes one planispiral whorl around the proloculus before extending in an irregular manner, while the second chamber of *T. bulbosa* extends and winds in an irregular manner immediately after leaving the proloculus.

Stratigraphic occurrence.—*Tolypammina cyclops* has previously been reported from the Lower Mississippian Rockford limestone, Jacobs Chapel shale, lower New Providence formation, and lower Cuyahoga formation of eastcentral United States (Conkin, 1961), and the Welden, Chappel, and Lodgepole limestones of western United States (Gutschick, Weiner, and

Young, 1961). In addition, we have found *T. cyclops* in the McCraney limestone at Seehorn Creek, Illinois. Gutschick (1962) reported this species from the lower Sappington formation of Montana.

Only one specimen of *Tolypammina cyclops* was found in the Louisiana limestone, in sample 2 from Locality 2.

Tolypammina gersterensis Conkin and Conkin, 1964 Pl. 13, figs. 7-10

Tolypammina gersterensis Conkin and Conkin, 1964, Micropaleont., vol. 10, No. 1, pp. 37, 38, pl. 2, figs. 42-44.

Description.—Test consists of a small hemispherical or hemiellipsoidal proloculus and a hemitubular, gradually enlarging second chamber which winds planispirally for one and one-half whorls and then extends away from the early portion in an irregular manner; wall moderately coarse-grained, composed of siliceous grains in siliceous cement; color of test, white to buff.

Measurements.—See Table 29 for measurements of *Tolypammina gersterensis* and for comparison with the original types.

Table 29. Measurements of *Tolypammina gersterensis* in mm. and comparison with the original types.

Plate 13	diam. coiled part	diam. proloc.	max. diam. tube	length test	locality and sample numbers
fig. 7	.420	.109	.168	.570	2 - 11
fig. 8	.193	.067	.118	.675	2 - 14
fig. 9	.487	.084	.134	-	5 - 1
fig. 10	.403	.101	.118	-	2 - 2
unfig.	.244	.033	.084	-	3 - 1
original types	.537- .780	.185- .201	.269- .386	-	

Comparison and affinities.—The present specimens are smaller than the original types in all respects; otherwise they are similar.

Tolypammina gersterensis is similar to *T. irregularis* Blumenstengel, 1961, from the Upper Devonian and Lower Carboniferous of Germany, but *T. irregularis* has two to three planispiral whorls while *T. gersterensis* has only one and one-half planispiral whorls. The two species appear to be similar in other respects.

Stratigraphic occurrence.—*Tolypammina gersterensis* was originally reported from the Northview and Sedalia formations of southwest-central Missouri (Conkin and Conkin, 1964). This species occurs rarely in the Louisiana limestone, in five samples from three localities. See Chart 1 for details of occurrance.

Tolypammina jacobschapelensis Conkin, 1961 Pl. 14, figs. 21-27

Tolypammina jacobschapelensis Conkin, 1961, Bull. Amer. Paleont., vol. 43, No. 196, pp. 303-305, pl. 22, figs. 16-21; pl. 27, fig. 5; fig. 23.

Tolypammina sperma Gutschick, Weiner, and Young, 1961, Jour. Paleont., vol. 35, No. 6, pp. 1217, 1218, pl. 150, fig. 12.

Description.—Test consists of an attached proloculus and an irregularly winding hemitubular to partially tubular second chamber; proloculus in the shape of half an egg, usually pointed at the initial end, though in some specimens the initial end is rounded; in some specimens the edges of the proloculus curve under and leave only a slitlike opening where attachment took place, apparently to a slender object; the original types were described as having the larger end of the egg-shaped proloculus initially, while several of the present specimens have the smaller end initially, giving the proloculus more of a heart-shape as described by Gutschick, Weiner, and Young (1961) under *Tolypammina sperma;* in addition, some present proloculi are equally rounded in outline with a pointed end; tube enlarges gradually and rather irregularly from its initial diameter which is about one-half to three-fourths the diameter of the proloculus; second chamber broken in all present specimens so its original length is not known, but fragments of tolypamminids (Pl. 13, figs. 18-20) found in the samples indicate by their great diameter that the tests may have been quite long; the attached side of the tube may be partially or entirely covered with a thin floor, or the floor may be absent; wall finely granular, of siliceous grains in siliceous cement; color of test, white to buff.

Measurements.—Table 30 gives the measurements of *Tolypammina jacobschapelensis* from the Louisiana limestone, and Table 31 gives a comparison with the original types and with its junior synonym, *T. sperma* Gutschick, Weiner, and Young, 1961.

Table 30. Measurements of figured specimens of *Tolypammina jacobschapelensis,* in mm.

Plate 14	diam. proloc.	length proloc.	diam. tube max.	diam. tube min.	length test	locality and sample numbers
fig. 21	.134	.151	.176	.101	1.020	2 - 17
fig. 22	.126	.134	.168	.084	1.090	2 - 19
fig. 23	.252	.302	.185	.134	.521	2 - 12
fig. 24	.134	.252	-	.055	-	
fig. 25	.185	.294	.118	.058	.657	5 - 1
fig. 26	.335	.436	.319	.185	1.370	2 - 23
fig. 27	.151	.218	.118	.067	.586	5 - 3
Plate 13						
fig. 18	-	-	.302	-	1.700	3 - 1
fig. 19	-	-	.386	-	1.445	3 - 1
fig. 20	-	-	.235	-	1.125	3 - 1

Table 31. Range in measurements of 24 specimens of *Tolypammina jacobschapelensis* and comparison with the original types and with *T. "sperma"*, in mm.

	T. jacobschapelensis		*T. "sperma"*
	Louisiana	original types	
diam. proloc.	.050-.335	.084-.269	.085-.150
length proloc.	.134-.436	.101-.285	.095-.350
min. diam. tube	.033-.185	.050-.201	-
max. diam. tube	.084-.319	.084-.285	.130-.450
length of test	up to 1.370	up to 2.10	up to 2.85

Comparison and affinities.—The specimens of *Tolypammina jacobschapelensis* from the Louisiana limestone compare well with the original types and with its junior synonym, *T. sperma,* which was noted by Gutschick, Weiner, and Young (1961) to occur in the "upper Rockford shale" of southern Indiana; the type locality for *T. jacobschapelensis* is at Jacobs Chapel in southern Indiana, in the Rockford limestone. There can be no doubt of the conspecificity of the two forms.

Stratigraphic occurrence.—*Tolypammina jacobschapelensis* is known from several Lower Mississippian formations: the Rockford limestone of southern Indiana and the lower New Providence formation of Kentucky (Conkin, 1961), the Welden limestone of Oklahoma and the Chappel limestone of Texas (Gutschick, Weiner, and Young, 1961), the Compton, Sedalia, and Pierson formations of Missouri (Conkin and Conkin, 1964), and the McCraney limestone at Seehorn Creek, Illinois.

Tolypammina jacobschapelensis was found abundantly in the Louisiana limestone, in 30 samples from five localities. See Chart 1 for details of occurrence.

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PLATES

EXPLANATION OF PLATE 12

Figure — All figures approximately X 50 — Page

1- 7. **Amphitremoida huffmani,** n. sp. 74
- 1a. Holotype, side view. No. 641182 USNM.
- 1b. Holotype, apertural view; aperture just above center.
- 2a, 2b, 3a, 3b. Paratypes, side and oblique apertural views. Nos. 641183, 641184 USNM.
- 4-7. Side view of paratypes. Nos. 641185—641188 USNM.

8-10. **Amphitremoida eisenacki,** n. sp. 73
- 8. Paratype, compressed; side view. No. 641189 USNM.
- 9. Holotype, compressed; side view. No. 641190 USNM.
- 10. Paratype, compressed and broken at upper end; side view. No. 641191 USNM.

11. **Amphitremoida ? sp.** 75

Compressed and fractured test showing large aperture at upper end (opposite aperture not visible from this side). No. 641192 USNM.

12-15. **Crithionina psammosphaeraeformis,** n. sp. 70
- 12. Holotype, five apertures visible; one on left is enlarged by breakage. No. 641193 USNM.
- 13-15. Paratypes. Nos. 641194—641196 USNM.

16-19. **Thurammina strickleri,** n. sp. 79
- 16. Holotype, showing 11 rather evenly spaced nipple-like apertural protuberances. No. 641197 USNM.
- 17-19. Paratypes, showing variation within the species. Dark spots are dark grains, not the apertures. Nos. 641198-641200 USNM.

20-27. **Thurammina adamsi,** n. sp. 77
- 20-24. Paratypes. All tests compressed or collapsed. Nos. 641201-641205 USNM.
- 25. Paratype, broken test showing thin wall. No. 641206 USNM.
- 26. Holotype, collapsed test showing irregularly shaped and spaced apertural protuberances. No. 641207 USNM.
- 27. Paratype, large compressed test from Gutschick's (1962) Louisiana material. No. 641208 USNM.

28-33. **Psammosphaera?** sp. B 76
- 28-31. Specimens showing coarse-grained test with dark organic material visible. Nos. 641209-641212 USNM.
- 32, 33. Specimens lacking dark organic material. Nos. 641213, 641214 USNM.

34,35. **Psammosphaera?** sp. C 77
- 34. Small specimen, no apertures visible. No. 641215 USNM.
- 35. Broken test with thin wall. No. 641216 USNM.

36-38. **Thuramminoides sphaeroidalis** Plummer, emend. Conkin 71
- 36. Interior view or broken test showing pitlike depressions. No. 641217 USNM.
- 37. Small test with ends of centripetal tube structure visible. No. 641218 USNM.
- 38. Medium-sized broken test with ends of centripetal tube structure visible. No. 641219 USNM.

39-41. **Psammosphaera?** sp. A 75
- 39, 41. Specimens showing fine-grained texture of wall. Nos. 641220, 641222 USNM.
- 40. Broken test showing thin wall. No. 641221 USNM.

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2a

2b

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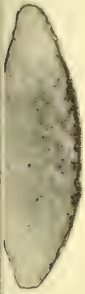
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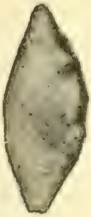
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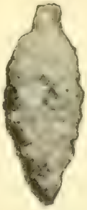
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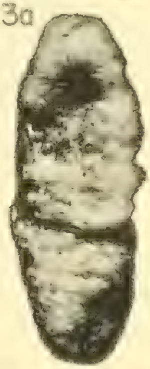
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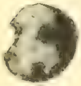
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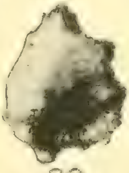
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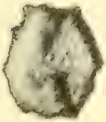
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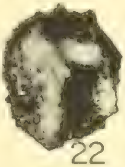
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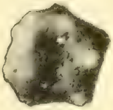
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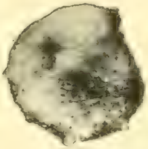
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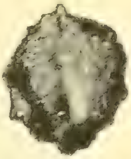
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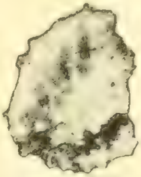
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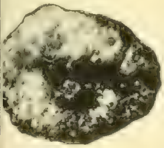
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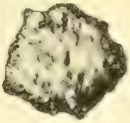
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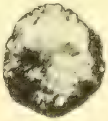
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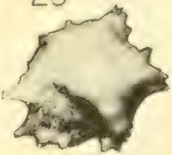
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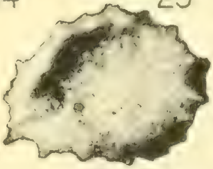
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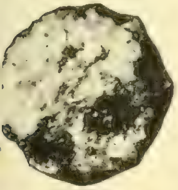
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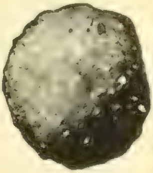
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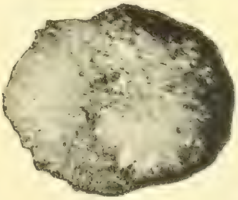
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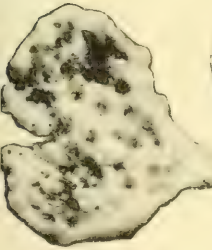
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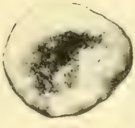
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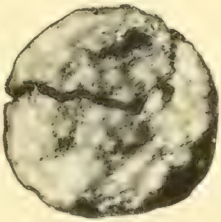
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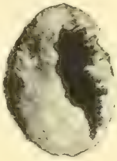
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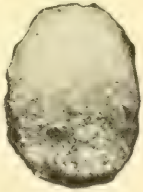
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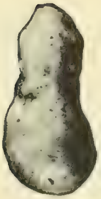
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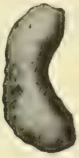
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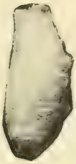
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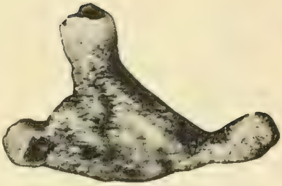
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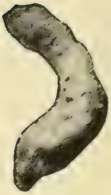
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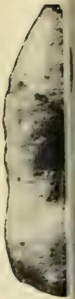
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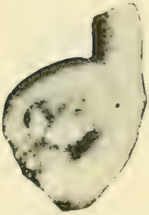
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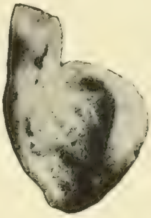
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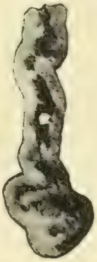
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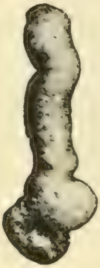
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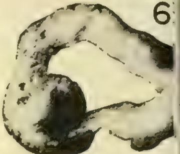
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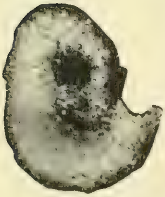
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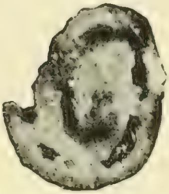
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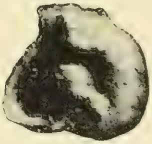
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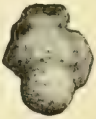
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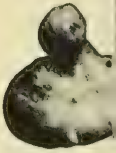
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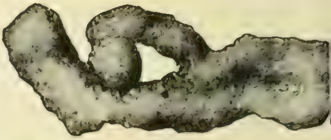
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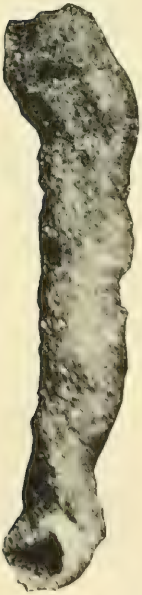
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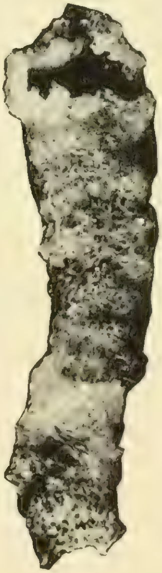
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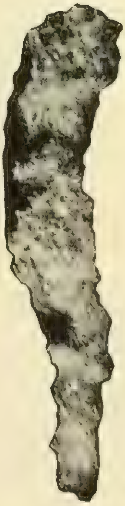
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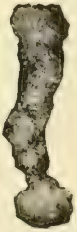
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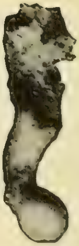
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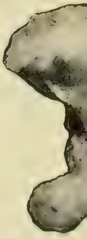
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EXPLANATION OF PLATE 13

Figure	All figures approximately X 50	Page
1- 6.	**Aschemonella louisiana,** n. sp.	83

1. Paratype, sausage-shaped test with single small aperture at each end. No. 641223, USNM.
2. Paratype, sausage-shaped; no aperture visible. No. 641224, USNM.
3. Paratype, lobe-shaped chamber, broken at upper end and with small aperture at lower end. No. 641225, USNM.
4. Holotype, showing three lobe-shaped chambers which appear to have "budded" from central chamber; upper chamber broken; left and right chambers have a small aperture at their ends. No. 641226, USNM.
5. Paratype, sausage-shaped test, with small simple aperture at upper end and small aperture on a tapering neck at lower end. No. 641227, USNM.
6. Paratype, sausage-shaped test, broken at upper end and with small aperture at lower end. Test cracked in upper portion. No. 641228, USNM.

7-10. **Tolypammina gersterensis** Conkin and Conkin.....96

7a, 7b, 9a, 9b. Two specimens showing upper and attached sides; extended portion of hemitube is broken off. Nos. 641229, 641231, USNM.

8a, 8b. Opposite sides of single rather complete and small specimen with small coiled portion. No. 641230, USNM.

10. Upper side of broken specimen. No. 641232, USNM.

11. **Tolypammina cyclops** Gutschick and Treckman.....95

Nearly complete specimen showing spherical proloculus followed by one planispiral whorl and extension of hemitubular second chamber. No. 641233, USNM.

12-17. **Tolypammina bulbosa** (Gutschick and Treckman), emend.....92

12, 13. Two broken specimens with spherical proloculus and short irregularly winding attached second chamber; more compactly wound than is typical. Nos. 641234, 641235, USNM.

14. Nearly complete specimen with spherical proloculus and hemitubular attached second chamber. No. 641236, USNM.

15-17. Broken tests with spherical or subspherical proloculus and extended second chamber. Nos. 641237-641239, USNM

18-20. Fragments of tolypamminids of unknown identity.....97

Probably *Tolypammina jacobschapelensis* which is the most abundant species of *Tolypammina* in the Louisiana. Large size indicates great length achieved by extended portion of Louisiana tolypamminids. No. 641240, USNM.

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Figure All figures approximately X 50 Page

1-20. **Hyperammina sappingtonensis** Gutschick..80

1-10. Microspheric forms. Specimen in fig. 1 is compressed. Nos. 641241-641250, USNM.

11-20. Megalospheric forms. Nos. 641251-641260, USNM.

21-27. **Tolypammina jacobschapelensis** Conkin..97

21, 22, 26. Fairly complete specimens of microspheric? forms, showing unattached side of test. Nos. 641261, 641262, 641266, USNM.

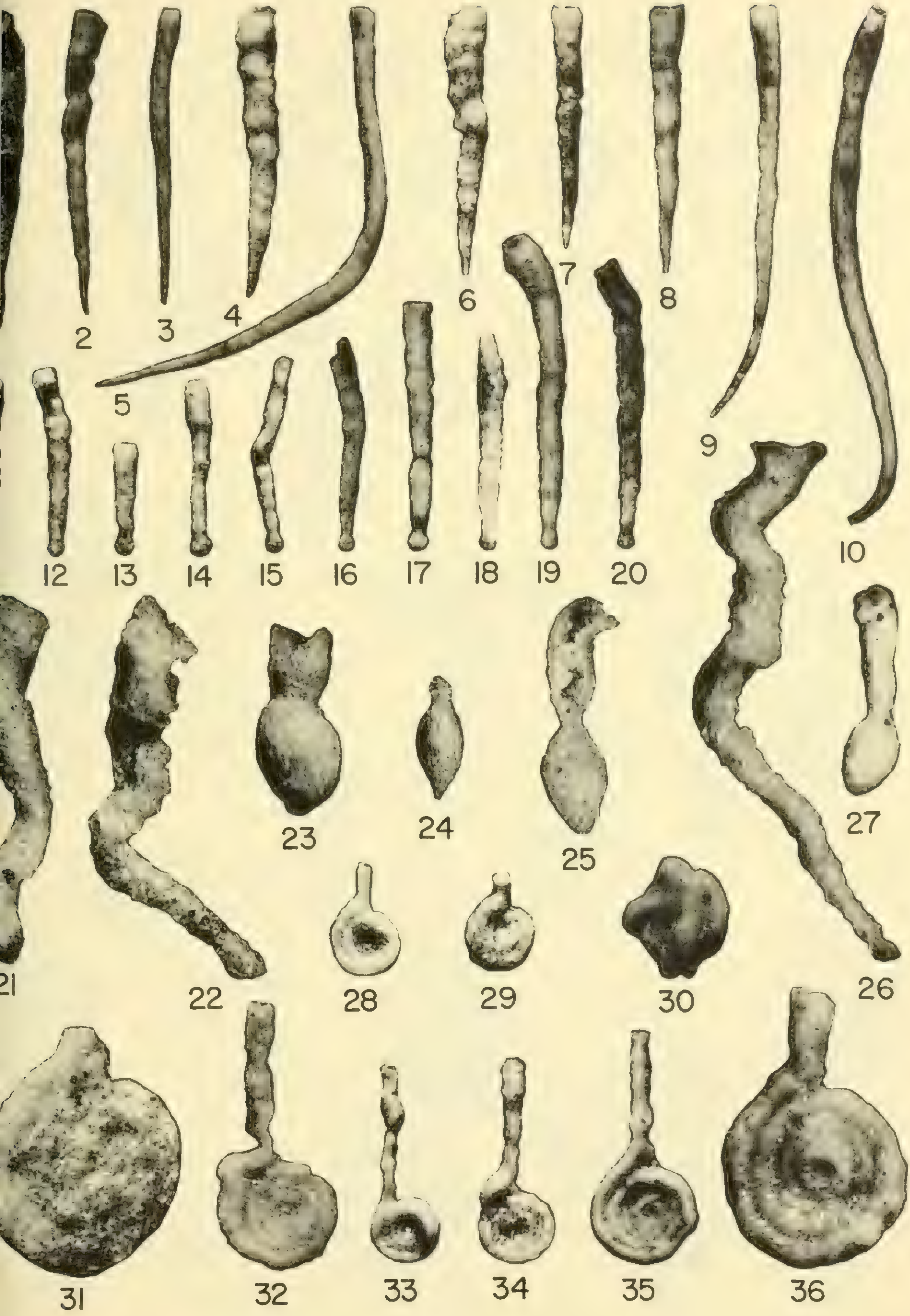
23-25, 27. Broken specimens of megalospheric? forms; fig. 25 shows attached side of test. Specimen in fig. 24 is from Louisiana float near the type locality of the Grassy Creek shale. Nos. 641263-641265, 641267, USNM.

28-36. **Ammodiscus longexsertus** (Gutschick and Treckman)........................91

28, 29, 31, 36. Small and large specimens with extended portion of second chamber partly broken off. Tests show some irregularity in the planispiral winding. Nos. 641268-641271, USNM.

30. Specimen with extended portion of second chamber winding around coiled portion. No. 641272, USNM.

32-35. Complete typical specimens. Fig. 33 shows specimen with innermost portion of whorls missing. Nos. 641273-641276, USNM.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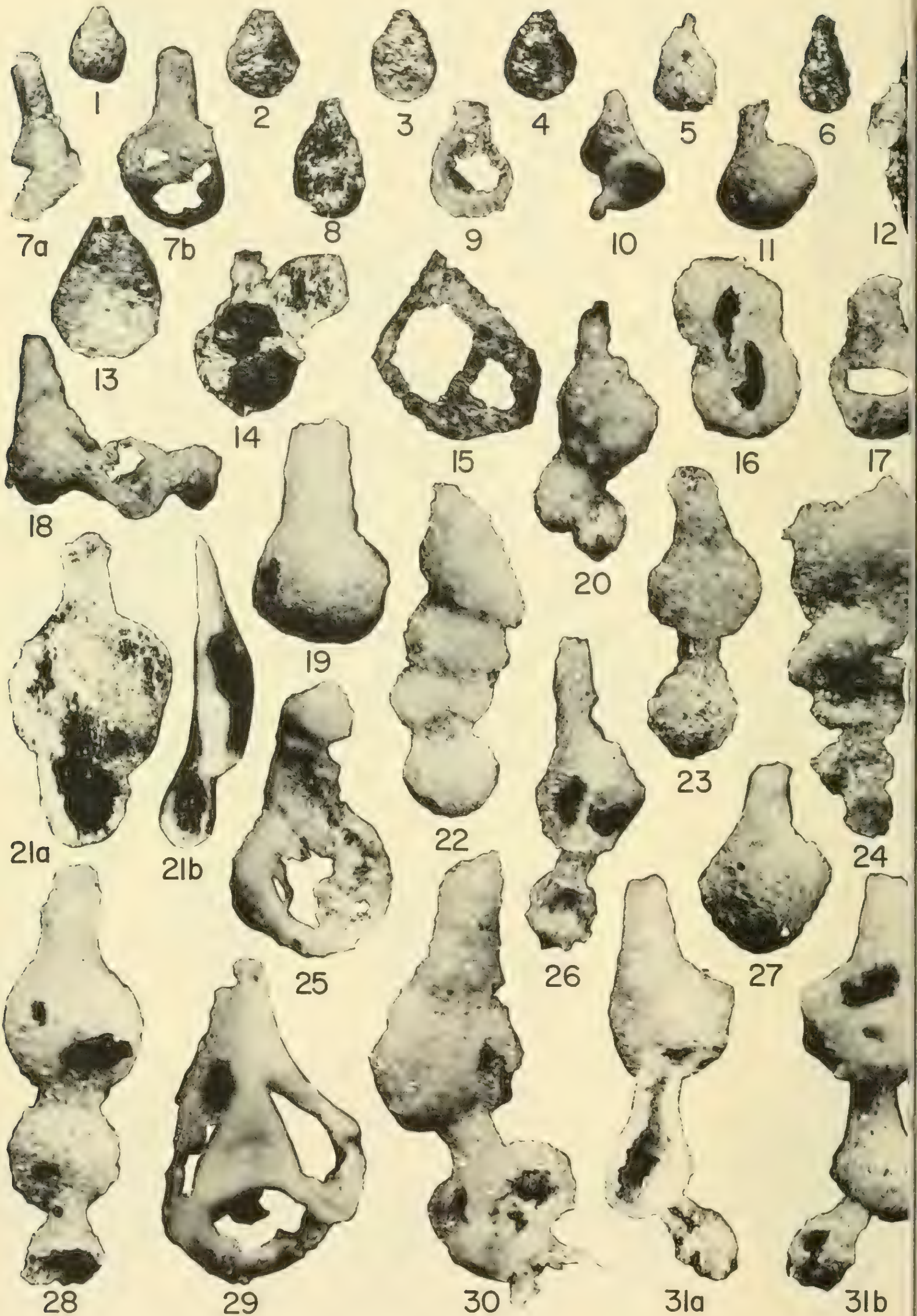
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EXPLANATION OF PLATE 15

Figure	All figures approximately X 50	Page
1-31.	**Oxinoxis ligula** (Gutschick, Weiner, and Young), emend.	87

1-6, 8, 13, 19, 27. Single chambers of pyriform to hemipyriform shape with solid or nearly solid test wall showing unattached side of test. (Specimen in fig. 8 was lost.) Nos. 641277-641285, USNM.

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10. Small specimen attached to a specimen of *Ammodiscus longexsertus*. No. 641289, USNM.

11. Unattached side of inflated hemispherical test with hemitubular neck. No. 641290, USNM.

12. Small single hemipyriform sievelike chamber attached to a slender object. No. 641291, USNM.

14. Specimen with two hemispherical sievelike chambers with ferruginous filling that bulges through openings in test wall on unattached side. No. 641292, USNM.

15. Specimen with netlike test; neck broken. No. 641293, USNM.

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18, 20, 22, 23, 28. Tests of two or three chambers showing unattached side and displaying variation seen within the species in nature and arrangement of chambers. Nos. 641295-641299, USNM.

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24. Compressed and distorted specimen. No. 641301, USNM.

25. Attached side of sievelike, hemipyriform chamber. No. 641302, USNM.

26. Attached side of test with two chambers and long apertural neck. No. 641303, USNM.

29. Netlike specimen with surfaces of attachment at several places on test as if it had been attached inside a small irregular space. No. 641304, USNM.

30. Broken test of three chambers with uppermost chamber seen from its unattached side and next lower chamber seen from its attached side. No. 641305, USNM.

31a, 31b. Opposite sides of single specimen of three chambers showing attachment at various places. No. 641306, USNM.

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LATE CENOZOIC SCAPHOPODS AND SERPULID POLYCHAETES FROM NORTHERN VENEZUELA

By

NORMAN E. WEISBORD

The Florida State University

June 19, 1964

Paleontological Research Institution
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LATE CENOZOIC SCAPHOPODS AND SERPULID POLYCHAETES FROM NORTHERN VENEZUELA

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The Florida State University
Research Associate, Paleontological Research Institution

PART 1. SCAPHOPODS

ABSTRACT

Fifteen fossil forms, including three new species, are described and illustrated. Two of the forms occur in the Guaiguaza clay, the others in the Mare and Playa Grande formations of the Cabo Blanco group. The scaphopods, though few in number, and often too fragmentary for definitive diagnosis, tend to confirm the age of the Guaiguaza clay as late Pliocene and the Mare and Playa Grande formations as early Pliocene.

INTRODUCTION

This is the third of a series of papers by the author dealing with late Cenozoic marine invertebrates from northern Venezuela. The first two papers were concerned, respectively, with the Gastropoda and Pelecypoda (Weisbord 1962, 1964), and the present one treats of the Scaphopoda[1] and Polychaetia.

The scaphopods described and illustrated in the present work were collected by the writer in 1955 and 1956 from the Playa Grande and Mare formations in the Cabo Blanco area, Distrito Federal, and from the Guaiguaza clay at La Salina de Guaiguaza west of Puerto Cabello in the State of Carabobo. Based on the per cent of gastropods and pelecypods that have survived to Recent time, and on the evidence of stratigraphy (Weisbord, 1957), the Playa Grande and Mare formations of the Cabo Blanco group are believed to be early Pliocene in age, and the Guaiguaza clay late Pliocene. The scaphopods tend to confirm these age determinations though few of them are complete enough to permit a definitive diagnosis to be made.

The work on the scaphopods was begun in August 1962, and the manuscript completed in May of 1963. For comparative studies and consultation of literature the writer visited the American Mueseum of Natural History, the Academy of Natural Sciences of Philadelphia, and the U. S. National Museum. The types and figured specimens are deposited with the Paleontological Research Institution, and duplicate specimens are in the paleontological collection of the Dept. of Geology at Florida State University.

---

[1] Appreciation is expressed to the National Science Foundation for its support of this study through its Research Grant NSF-8699, awarded 15 November 1959. The monograph on the pelecypods was written under this same grant.

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A number of colleagues have been helpful to me in the execution of this work, and among those, I wish to express my appreciation to William K. Emerson of the American Museum of Natural History for examining several of the Venezuelan scaphopods which I brought to the Museum for his diagnosis: to R. Tucker Abbott, Horace G. Richards, Robert Robertson, and Virginia Orr of the Academy of Natural Sciences of Philadelphia for placing at my disposal the Academy's Recent and fossil collections of Scaphopoda in which are contained many of the types of the late Henry A. Pilsbry; to Harald A. Rehder and Joseph Rosewater of the U. S. National Museum who afforded me every facility for studying the Museum's extensive collections, including that of John B. Henderson; and to Katherine V. W. Palmer of the Paleontological Research Institution for editing the manuscript and attending to its publication.

LOCALITIES

The localities from which the scaphopods were collected, and the formation exposed at each locality are listed below. The letter preceding the locality description is also given as a prefix to each species in the collection. All of the localities except La Salina de Guaiguaza are shown on the geologic map accompanying the writer's paper (Weisbord, 1957) titled "Notes on the geology of the Cabo Blanco area, Venezuela." On the 1957 map field stations are designated by the letter "W", and some of the locality descriptions refer to these stations. For a complete list of all of the localities from which the northern Venezuelan collections were made, the reader is referred to the author's publications of 1962 and 1964.

C. Near south shore of La Salina de Guaiguaza, 5.6 kilometers west of Puerto Cabello, State of Carabobo. The fossils were collected in the Guaiguaza clay in a drainage ditch about one meter in depth.

F. Hillside above west bank of Quebrada Mare Abajo at W-14. Upper Mare formation.

G. Hillside above west bank of Quebrada Mare Abajo near W-14. Mare formation.

H. 15 meters south of axis of Punta Gorda anticline at W-25. Mare formation.

I. Hillside above west bank of Quebrada Mare Abajo at W-13. Lower Mare formation.

J. Banks of small dry stream 100 meters west of Quebrada Mare Abajo and 125 meters west-southwest of the intersection of Quebrada Mare Abajo and the coast road. Lower Mare formation.
K. Bluff 125 meters west of the intersection of the Playa Grande Yachting Club road and coast road, and about 95 meters due south of shoreline. Playa Grande formation (Catia member).
O. Dip slope 100 meters west of Costa fault and 130 meters south of shoreline at W-22. Playa Grande formation (Catia member).
Q. Quebrada Las Pailas at, and in the vicinity of W-14. Playa Grande formation (Maiquetía member).
R. Quebrada Las Bruscas at W-26, approximately 125 meters upstream from junction with Quebrada Las Pailas. Playa Grande formation (Maiquetía member).
S. Near and on *Lithothamnium* bioherm at W-23, north flank of Punta Gorda anticline. Playa Grande formation (Maiquetía member).
T. Banks of stream 250 meters south-southwest of the mouth of Quebrada Las Pailas and 255 meters east-northeast of wireless station. Upper Mare formation.
X. Quebrada Las Pailas at W-3, south side of Mare Abjao fault near its intersection with the Bruscas fault. Playa Grande formation (Maiquetía member).

LIST OF SCAPHOPODS COLLECTED IN NORTHERN VENEZUELA

The scaphopods described in the present work are listed below. Under the heading of Formation, the abbreviation Sal refers to the Guaiguaza clay, Ma to the Mare formation, PGm to the Playa Grande formation (Maiquetía member), and PGc to the Playa Grande formation (Catia member).

Species	*Formation*	*Geologic range of known species*
Dentalium (Dentalium) cf. texasianum rioense Henderson	Sal	Recent
Dentalium (Graptacme) semistriolatum Guilding	Ma	Recent
Dentalium (Antalis) disparile d'Orbigny	Ma	Recent
Dentalium (Antalis) aff. antillarum d'Orbigny	PGm	Pliocene-Recent
Dentalium (Antalis) sp.	Sal	
Dentalium (Antalis?) sp.	Ma	

? Dentalium sp. indet.	PGc	
Fustiaria (Laevidentalium ?) venezuelana Weisbord, n. sp.	PGm	
Fustiaria (Laevidentalium) perlongum ? Dall	Ma; PGm	Recent
Fustiaria (Laevidentalium) sp.	Ma	
Cadulus (Gadila) bruscasensis Weisbord, n. sp.	Ma; PGm	
Cadulus (Gadila) playagrandensis Weisbord, n. sp.	Ma; PGm	
Cadulus (Polyschides) quadridentatus (Dall)	Ma;PGm	Upper Miocene-Recent
Cadulus (Polyschides) tetraschistus ? (Watson)	PGc	Recent
Cadulus sp. indet.	PGc	Recent

ANALYSIS OF THE SCAPHOPOD FAUNA

The scaphopods in themselves are too few in number to permit age determinations to be made, but based on the percentage of species that have survived to Recent time, they seem to confirm the ages established from the gastropods and pelecypods. No scaphopods were found among the Recent invertebrates collected on the beaches nor were any found in the Abisinia formation of Pleistocene age. However, two or more species have been described from the Guaiguaza clay, from the Mare formation, and from the Playa Grande formation. A synthesis of all of the data thus far considered suggests that the Guaiguaza clay is late Pliocene in age, and that the Mare and Playa Grande formations are early Pliocene in age.

Guaiguaza clay

This is a gray and brown clay lying immediately below the surface at the south end of Salina de Guaiguaza. The scaphopods found therein are the following:

Species	*Geologic range of known species*	*Geologic range of nearest related species*
Dentalium (Dentalium) cf. texasianum rioense Henderson	Recent	
Dentalium (Antalis) sp.		Upper Miocene-Recent

One, and possibly both, of the two fossil scaphopods found in the Guaiguaza clay also occur in the Recent fauna. This represents at least 50 per cent of the species which have survived to Recent time and is roughly the same percentage that obtains for the combined total of gastropods and pelecypods, as shown in the composite summary following:

TABLE 1. MOLLUSCA OF THE GUAIGUAZA CLAY

Class	*Total number of species examined*	*Number of species known to be still living*	*Per cent of Recent species*
Gastropoda	25	9	36
Pelecypoda	14	11	78
Scaphopoda	2	1	50
Total	41	21	51

With roughly 51 per cent of the mollusks from the Guaiguaza clay still living, and with many of the other fossils distinct from, but analogous to forms that are living today, it is postulated that the clays were deposited before the Pleistocene epoch and relatively late in Pliocene time.

Mare formation.

The Mare formation is 12 to 19 meters thick and consists mostly of soft homogeneous siltstone, with a few meters of coarse friable sandstone at the base. The Mare formation is disconformably overlain by the Abisinia formation and is underlain by the Playa Grande formation. Where observed, the contact between the Mare formation and the underlying Playa Grande formation is one of unconformity. The Mare formation is highly fossiliferous, containing 144 species of gastropods, 82 species of pelecypods, and 8 species of scaphopods. The scaphopods are the following:

Species	*Geologic range of known species*	*Geologic range of nearest related species*
Dentalium (Graptacme) semistriolatum Guilding	Recent	
Dentalium (Antalis) disparile d'Orbigny	Upper Miocene-Recent	
Dentalium (Antalis) ? sp.		Middle Miocene (?)-Recent
Fustiaria (Laevidentalium) perlongum ? Dall	Recent	
Fustiaria (Laevidentalium) sp.		Lower-middle Miocene; Recent
Cadulus (Gadila) bruscasensis Weisbord, n. sp.		Lower-middle Miocene; Recent
Cadulus (Gadila) playagrandensis Weisbord, n. sp.		Lower-middle Miocene; Recent
Cadulus (Polyschides) quadridentatus (Dall)	Upper Miocene (?)-Recent	

Of the eight scaphopods described from the Mare formation, four, or 50 per cent are also Recent, four are closely related to species in the Miocene and Recent, and one is probably the same as a lower-middle Miocene species from the Dominican Republic and Haiti.

The proportion of Mare mollusks that have continued to Recent time is given in the following table.

TABLE 2. MOLLUSCA OF THE MARE FORMATION

Class	*Total number of species examined*	*Number of species known to be still living*	*Per cent of Recent species*
Gastropoda	144	25-50	17-34
Pelecypoda	82	32-38	39-46
Scaphopoda	8	4	50
Total	234	61-92	26-39

As there is a judgment factor involved in determining whether a fossil species is the same as, or different than a closely related living species, the proportion of Mare mollusks that are still living is given in the range of 26 to 39 per cent. To the writer this suggests that the Mare formation occupies a lower Pliocene position in the time scale.

Playa Grande formation (Maiquetía member).

The Playa Grande formation underlies the Mare formation and is separated from the Mare formation by a distinct stratigraphic unconformity. This unconformity, however, is not sensitively reflected in the fossils, as many of them are common to the two formations; also, the percentage of species of all of the Mollusca that have survived to Recent time is roughly the same in both formations. The upper complex of the Playa Grande formation, known as the Maiquetía member, is about 34 meters thick and is made up of shales, siltstones, sandstones, conglomerates, and occasional bioherms of calcareous algae. Mollusks are moderately abundant, and among those the following six species of scaphopods have been described:

Species	*Geologic range of known species*	*Geologic range of nearest related species*
Dentalium (Antalis) aff. antillarum d'Orbigny	Pliocene-Recent	
Fustiaria (Laevidentalium ?) venezuelana Weisbord, n. sp.		Recent
Fustiaria (Laevidentalium) perlongum ? Dall	Recent	
Cadulus (Gadila) bruscasensis Weisbord, n. sp.		Lower-middle Miocene-Recent
Cadulus (Gadila) playagrandensis Weisbord, n. sp.		Lower-middle Miocene-Recent
Cadulus (Polyschides) quadridentatus (Dall	Upper Miocene (?)-Recent	

Three of the six scaphopod species (50 per cent) are living to-day, and three of the species are new but closely related to Recent forms.

The number of mollusks described from the Maiquetía member and the percentage of the species which are also Recent are given in the following table.

TABLE 3. MOLLUSCA OF THE MAIQUETÍA MEMBER
(PLAYA GRANDE FORMATION)

Class	*Total number of species examined*	*Number of species known to be still living*	*Per cent of Recent species*
Gastropoda	82	8-23	10-28
Pelecypoda	53	23-31	43-58
Gastropoda	6	3	50
Total	141	34-57	24-40

Playa Grande formation (Catia member)

Because of faults and Quaternary cover, the stratigraphic relationship of the Catia and Maiquetía members of the Playa Grande formation is not clearly established. Indirect evidence, however, suggests that the Catia member constitutes the lower and more preponderant part of the Playa Grande formation. The Catia member is made up of assorted rock types including calcareous siltstones and sandstones, conglomerates, shales, and limestones. Many of the beds are fossiliferous, and there are some thin coquinas. The thickness of the Catia member is 156 to 233 meters, and it overlies the nonfossiliferous Las Pailas formation with pronounced angular unconformity.

Species	*Geologic range of known species*	*Geologic range of nearest related species*
Cadulus (Polyschides) tetraschistus ? (Watson)	Recent	
Cadulus, sp. indet.		?

Cadulus tetraschistus (Watson) is a living shallow-water species ranging from Brazil to Argentina in depths of 7 to 25 fathoms. The single specimen from the Catia formation is poorly preserved but seems so similar to *C. tetraschistus* that it is tentatively identified as that species.

The species of all Mollusca collected from the Catia member, and the percentage of those occurring in the Recent fauna, are given in Table 4, below.

TABLE 4. MOLLUSCA OF THE CATIA MEMBER
(PLAYA GRANDE FORMATION)

Class	*Total number of species examined*	*Number of species known to be still living*	*Per cent of Recent species*
Gastropoda	6	0-2	0-33
Pelecypoda	26	8-10	31-40
Scaphopoda	2	1	50
Total	34	9-13	27-40

Correlating the data in Tables 1-4 with available stratigraphic information, the writer concludes that the Guaiguaza clay is of late Pliocene age and the Mare and Playa Grande formations of early Pliocene age.

SYSTEMATIC DESCRIPTIONS

SCAPHOPODA

DENTALIIDAE

Dentalium (Dentalium) cf. **texasianum rioense** Henderson

Pl. 16, fig. 1; Pl. 18, fig. 1

1920. *Dentalium* (*Dentalium*) *texasianum rioense* Henderson, U. S. Nat. Mus., Bull. 111, p. 29, pl. 2, figs. 2-3.

1949. *Dentalium* (*Dentalium*) *texasianum rioense* Henderson, Lange de Morretes, Mus. Paranaense, Arq., vol. 7, art. 2, p. 53.

1953. *Dentalium* (*Dentalium*) *texasianum rioense* Henderson, Haas, Fieldiana-Zoology, vol. No. 20, p. 203.

Fragments representing the posterior portion of the tube are hexagonal in cross section around the circumference and circular within the annulus. The shell is white, opaque, and strong, the thickness gradually decreasing anteriorward, the diameter slowly increasing anteriorward. The angulation is produced by six sharp longitudinal ribs, separated by wide, hardly concave to flat, interspaces. The interspaces forming the dorso-lateral faces of the tube are nearly imperceptibly narrower than the other four faces which are about equal. The shell is smooth save for transverse growth lines and faintly impressed annular growth marks at unequal intervals. One of the specimens (C301a) has a regrown tube within the posterior orifice. On none of the fragments is the posterior tip or the anterior end of the tube present.

Dimensions.—Specimen C301a, length of fragment 3.8 mm.; diameter at larger end 0.8 mm.

Locality.—Guaiguaza clay, near south shore of La Salina de Guaiguaza, six kilometers west of Puerto Cabello, State of Carabobo. Five incomplete specimens.

Remarks.—I have examined the types of *D. texasianum rioense* (U. S. Nat. Mus., No. 96114), and so far as they can be compared the Venezuelan fossils are precisely the same as the Recent form described by Henderson. It must be noted, however, that the posterior end of the Venezuelan tube is also similar to such other species with a hexagonal tip as *D. texasianum texasianum* Philippi, *D. gouldii* Dall, and *D. rebeccaense* Henderson from the Western Atlantic, although in my judgment the best match is with *D. t. rioense.* Along the Pacific coast from Baja California to Colombia is yet another analagous species—*D. oerstedii* Mörch (1861, Malakozool.

Blätter, vol. 7, p. 177)—but Recent specimens of *D. oerstedii* from Colon, contained in the collection at the Academy of Natural Sciences of Philadelphia, attain a larger size than the *D. texasianum* group and the interstitial riblets originate nearer the posterior end of the tube than on *D. t. rioense*. *Dentalium oerstedii* has been recorded also from the Pleistocene of Magdalena Bay, México, by Jordan and Hertlein (1936, Contrib. Dept. Geol. Stanford Univ., vol. 1, No. 4, p. 148).

Range and distribution.—The Recent *D. texasianum rioense* Henderson has been reported from east of Rio de Janeiro at a depth of 50 fathoms, in blue mud; from the littoral of Ilha Grande, Rio de Janeiro; and from San Sebastian, also in Brazil. If the identity is established this is the first notice of the occurrence of *D. t. rioense* as a fossil.

Dentalium (Graptacme) semistriolatum Guilding Pl. 16, figs. 3-6

1819. *? Dentalium semistriatum* Turton, A Conchological Dictionary of the British Islands, p. 39, pl. 18, fig. 68.
1826. *? Dentalium nebulosum* Deshayes, Soc. Hist. Nat. Paris, Mém., vol. 2, p. 369, pl. 16, fig. 20. Not of Gmelin.
1834. *Dentalium semistriolatum* Guilding, Linnean Soc. London, Trans., vol. 17, No. 5, p. 34, pl. 3, figs. 1-5.
1843. *Dentalium semistriolatum* Guilding, Linnean Soc. London, Trans., vol. 17, p. 8, pl. 3, fig. 12. Not of Deshayes.
1843. *? Dentalium nebulosum* Deshayes, Chenu, Illustrations Conchyliologiques, vol. 3, p. 5, pl. 8, fig. 4.
1843. *Dentalium semistriolatum* Guilding, Chenu, Illustrations Conchyliologiques, vol. 3, p. 7, pl. 4, figs. 14-15.
1850. *Dentalium semistriolatum* Turton, Forbes and Hanley, A History of the British Mollusca and their Shells, vol. 2, p. 454.
1860. *? Dentalium nebulosum* Deshayes, Sowerby, Thes. Conchyl., vol. 3, p. 98, pl. 225, fig. 58.
1864. *? Dentalium semistriatum* Guilding, Krebs, The West Indian Marine Shells, p. 91.
1873. *? Dentalium nebulosum* Deshayes, Sowerby, [in] Reeve, Conch. Icon., vol. 18, pl. 17, sp. 53.
1878. *? Dentalium semistriatum* Guilding, Mörch, Catalogue of the West-India Shells, p. 14.
1891. *? Dentalium semistriatum* Guilding, Baker, Acad. Nat. Sci. Philadelphia, Proc., vol. 43, p. 49.
1896. *? Dentalium nebulosum* Deshayes, Clessin, Syst. Conchylien-Cabinet, vol. 6, pt. 5, p. 19, pl. 5, fig. 5.
1897. *? Dentalium (Graptacme) semistriatum* Turton, Pilsbry and Sharp, Man. Conch., vol. 17, p. 90, pl. 16, figs. 51-53.
1920. *Dentalium (Graptacme) semistriolatum* Guilding, Henderson, U. S. Nat. Mus., Bull. 111, pp. 69-70, pl. 11, figs. 1-3, 8-9.
1922. *Dentalium (Graptacme) semistriolatum* Guilding, Maury, Bull. Amer. Paleont., vol. 9, No. 38, p. 37.
1934. *Dentalium (Graptacme) semistriolatum* Guilding, Johnson, Boston Soc. Nat. Hist., Proc., vol. 40, No. 1, p. 61.
1937. *Dentalium semistriolatum* Guilding, Smith, East Coast Marine Shells, p. 72, pl. 55, figs. 13,17.

1954. *Dentalium* (*Graptacme*) *semistriolatum* Guilding, Abbott, American Seashells, p. 331.

1955. *Dentalium* (*Graptacme*) *semistriolatum* Guilding, Turner, Woods Hole Oceanogr. Inst., Contrib., No. 779, p. 313.

1958. *Dentalium* (*Graptacme*) *semistriolatum* Guilding, Abbott, Acad. Nat. Sci. Philadelphia, Mon. No. 11, pp. 108-109.

1959. *Dentalium semistriolatum* Guilding, Nowell-Usticke, A Check List of the Marine Shells of St. Croix, p. 90.

1961. *Dentalium* (*Graptacme*) *semistriolatum* Guilding, Warmke and Abbott, Caribbean Seashells, p. 224, text fig. 34a.

The Venezuelan fossil referred to this species is broken away, with but the posterior fourth or so remaining, that, however, in excellent preservation. The shell is moderately thick, gently arched, slowly and evenly tapering, subvitreous but becoming dense and white at the anterior termini of the longitudinal riblets. Cross section circular. Posterior orifice regrown, bearing an apical slit on the side about midway between the dorsal and ventral faces, the slit extending down the side for a distance of 3.7 mm. from the apex. The sculpture consists of fine longitudinal riblets, more or less equal, but in places with a minor thread between them. In all there are about 40 riblets around the tip and about 56 at their termination some 7 mm. below the apex of the tube. The anterior end of the specimen is smooth except for faint, fairly regular, transverse growth lines which traverse the whole of the tube. The tube is also encircled by opaque milky white bands or maculations.

Dimensions.—Specimen I366a, length (approx. one-fourth of total) 8.3 mm.; diameter at larger end 1.25 mm. Specimen T304a, length of fragment 3.6 mm.; diameter at larger end 0.9 mm.

Localities.—Lower Mare formation at W-13, on hillside above west bank of Quebrada Mare Abajo. One specimen. Upper Mare formation, in stream 250 meters south-southwest of the mouth of Quebrada Las Pailas. Two specimens (fragments).

Remarks.—Although only the posterior fourth or so of the complete shell is present on specimen I366a, the characters are identical with those of the Recent *D. semistriolatum* of Guilding. The lateral location of the apical slit serves to distinguish *D. semistriolatum* from the Miocene to Recent *D. eboreum* Conrad (see Henderson, 1920, pp. 66-68, pl. 10, figs. 3,4,5,8,9; pl. 11, fig. 6) on which the apical slit, if present, occurs on the convex or ventral face. As *D. eboreum* is similar to *D. semistriolatum* except in the position of the slit, and as the Recent *D. eboreum* also extends to the southern Caribbean, references to that species are given below:

1846. *Dentalium eboreum* Conrad, Acad. Nat. Sci. Philadelphia, Proc., vol. 3, p. 27.
1885. *Dentalium leptum* Bush, Connecticut Acad. Arts and Sci., Trans., vol. 6, No. 11, pp. 470-471, pl. 45, figs. 18,18a.
1885. *Dentalium leptum* Bush, U. S. Com. Fish and Fisheries, Rept. of the Commissioner for 1883, p. 586.
1889. *Dentalium leptum* Bush, Dall, Mus. Comp. Zool., Bull., vol. 17, p. 421.
1889. *Dentalium leptum* Bush, Dall, U. S. Nat. Mus., Bull. 37, p. 76.
1889. *Dentalium matara* Dall, Mus. Comp. Zool., Bull., vol. 18, p. 420.
1889. *Dentalium matara* Dall, U. S. Nat. Mus., Bull. 37, p. 76.
1892. *Dentalium leptum* Bush, Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 2, p. 440.
1897. *Dentalium eboreum* Conrad, Pilsbry and Sharp, Man. Conch., vol. 17, p. 89, pl. 16, figs. 47,48,49,55,56.
1897. *Dentalium leptum* Bush, Pilsbry and Sharp, Man. Conch., vol. 17, p. 89, pl. 16, fig. 50.
1897. *Dentalium matara* Dall, Pilsbry and Sharp, Man. Conch., vol. 17, p. 105, pl. 18, figs. 14-18.
1900. *Dentalium* (*Laevidentalium*) *matara* Dall, Dautzenberg, Soc. Zool. France, Mém., vol. 13, p. 221.
1901. *Dentalium matara* Dall, Dall and Simpson, U. S. Fish Com., vol. 20 for 1901, pt. 1, p. 456.
1903. *Dentalium leptum* Bush, Dall, U. S. Nat. Mus., Bull. 37, p. 76.
1903. *Dentalium matara* Dall, U. S. Nat. Mus., Bull. 37, p. 76.
1920. *Dentalium* (*Graptacme*) *eboreum* Conrad, Henderson, U. S. Nat. Mus., Bull. 111, pp. 66-68, pl. 10, figs. 3,4,5,8,9; pl. 11, fig. 6.
1921. *Dentalium eboreum* Conrad (?), Pilsbry, Acad. Nat. Sci. Philadelphia, Proc., vol. 73, p. 400.
1922. *Dentalium* (*Graptacme*) *eboreum* Conrad, Maury, Bull. Amer. Paleont., vol. 9, No. 38, p. 37.
1934. *Dentalium* (*Graptacme*) *eboreum* Conrad, Johnson, Boston Soc. Nat. Hist., Proc., vol. 40, No. 1, p. 61.
1936. *Dentalium eboreum* Conrad, Lermond, Check List of the Marine Shells of Florida, Gulfport, p. 24.
1937. *Dentalium eboreum* Conrad, Smith, East Coast Marine Shells, pp. 71-72, pl. 65, figs. 18,18a.
1944. *Dentalium eboreum* Conrad, Hackney, Nautilus, vol. 58, No. 2, p. 60.
1947. *Dentalium* (*Graptacme*) *eboreum* Conrad, Gardner, U. S. Geol. Sur., Prof. Paper 142-H, pp. 626-627.
1953. *Dentalium* (*Graptacme*) *eboreum* Conrad, Olsson and Harbison, Acad. Nat. Sci. Philadelphia, Mon. No. 8, p. 154.
1954. *Dentalium* (*Graptacme*) *eboreum* Conrad, Abbott, American Seashells, p. 331, fig. 69e.
1955. *Dentalium* (*Graptacme*) *eboreum* Conrad, Turner, Woods Hole Oceanogr. Inst., Contrib., No. 779, p. 313.
1955. *Dentalium* (*Graptacme*) *eboreum* Conrad, Perry and Schwengel, Marine Shells of the Western Coast of Florida, p. 100, pl. 20, figs. 132a,b.
1958. *Dentalium eboreum* Conrad, Moore, Nautilus, vol. 71, No. 4, p. 128.
1959. *Dentalium eboreum* Conrad, Nowell-Usticke, A Check List of the Marine Shells of St. Croix, p. 90.
1961. *Dentalium eboreum* Conrad, Moore, Gulf Research Repts., vol. 1, No. 1, p. 14.
1961. *Dentalium* (*Graptacme*) *eboreum* Conrad, Warmke and Abbott, Caribbean Seashells, p. 224.
1962. *Dentalium* (*Graptacme*) *eboreum* Conrad, Emerson, Jour. Paleont., vol. 36, No. 3, pp. 470-471, pl. 77, figs. 3a-3d.

D. eboreum Conrad is said to range from the middle Miocene to Recent. The living species is found from Cape Hatteras, North Carolina, to the Guajira Peninsula of Colombia, South America, at depths of 2 to 100 fathoms. The fossil form of *D. eboreum* occurs in the Pliocene and middle Miocene of Florida, and questionably in the middle Miocene of the Dominican Republic.

Range and distribution.—The Recent *D. semistriolatum* Guilding ranges from southern Florida to the West Indies in depths of 1 to 90 fathoms. This is the first record of its occurrence as a fossil in the Caribbean region.

Dentalium (Antalis) disparile d'Orbigny

Pl. 16, figs. 7,8; Pl. 17, figs. 1,2; Pl. 18, figs. 4,5

1842. *Dentalium disparile* d'Orbigny, [in] La Sagra, Hist. phys., polit. et nat. l'Ile de Cuba, vol. 2, Mollusques, p. 202, Atlas, pl. 25, figs. 14-17.
1845. *Dentalium disparile* d'Orbigny, [in] La Sagra, Hist. Fís., Polít. y Nat. Isla de Cuba, pt. 2, vol. 5, Moluscos, p. 274.
1864. *Dentalium disparile* d'Orbigny, Krebs, The West Indian Marine Shells, p. 91.
1867. *Dentalium disparile* d'Orbigny, Guppy, Sci. Assoc. Trinidad, Proc., pt. 3, p. 160.
1878. *Dentalium disparile* Orbigny, Arango y Molina, Contribución a la Fauna Malacológica Cubana, p. 232.
1878. *Dentalium disparile* Orbigny, Mörch, Catalogue of West-India Shells, p. 14, No. 951.
1889. *Dentalium disparile* Orbigny, Dall, U. S. Nat. Mus., Bull. 37, p. 76.
1889. *Dentalium disparile* d'Orbigny, Simpson, Davenport Acad. Nat. Sci., Proc., vol. 5, p. 70.
1892. *Dentalium disparile* Orbigny, Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 2, p. 440 (part).
1897. *Dentalium disparile* d'Orbigny, Pilsbry and Sharp, Man. Conch., vol. 17, p. 56 (in part), pl. 14, fig. 19.
1897. *Dentalium disparile* Orbigny, Pilsbry and Sharp, Acad. Nat. Sci. Philadelphia, Proc., vol. 49, p. 471.
1901. *Dentalium disparile* d'Orbigny, Dall and Simpson, U. S. Fish Com., Bull., vol. 20 for 1900, pt. 1, p. 456.
1903. *Dentalium disparile ?* Orbigny, Vanatta, Acad. Nat. Sci. Philadelphia, Proc., vol. 55, p. 757.
1917. *Dentalium disparile* d'Orbigny, Pilsbry and Brown, Acad. Nat. Sci. Philadelphia, Proc., vol. 69, p. 37.
1920. *Dentalium* (*Antalis*) *disparile* Orbigny, Henderson, U. S. Nat. Mus., Bull. 111, pp. 47-49, pl. 6, figs. 4-8.
1922. *Dentalium* (*Antalis*) *disparile* d'Orbigny, Maury, Bull. Amer. Paleont., vol. 9, No. 38, p. 35.
1934. *Dentalium disparile* Orbigny, Johnson, Boston Soc. Nat. Hist., Proc., vol. 40, No. 1, p. 60.
1936. *Dentalium disparile* Orbigny, Lermond, Check List of Florida Marine Shells, Gulfport, p. 24.
1947. *Dentalium* (*Antalis*) *disparile* d'Orbigny, Gardner, U. S. Geol. Sur., Prof. Paper 142-H, pp. 625,626.

1949. *Dentalium* (*Antalis*) *disparile* Orbigny, Lange de Morretes, Mus. Paranaense, Arq., vol. 7, art. 1, p. 53.

1953. *Dentalium* (*Antalis*) *disparile* Orbigny, Haas, Fieldiana-Zoology, vol. 34, No. 20, p. 203.

1955. *Dentalium* (*Antalis*) *disparile* d'Orbigny, Turner, Woods Hole Oceanogr. Inst., Contrib., No. 779, p. 311.

1958. *Dentalium disparile* d'Orbigny, Olsson and McGinty, Bull. Amer. Paleont., vol. 39, No. 177, p. 23.

1961. *Dentalium* (*Dentale*) *disparile* Orbigny, Warmke and Abbott, Caribbean Seashells, p. 225.

Shell fairly large, moderately and evenly curved, gently tapering, the narrowed posterior end generally thicker than the anterior end. Tip hexagonal in cross section, the peristome subcircular, the annulus also subcircular throughout the length of the tube. Apical area sculptured by six, sharp, nearly equidistant, longitudinal ribs separated by smooth nearly flat interspaces. A short distance below the apex the ribs become so disposed as to leave two broader intercostal spaces on the concave and three narrower spaces on the convex side. The intercalation of secondary longitudinal ribs begins nearer the apex in the three intercostal spaces on the convex side of the tube than it does in the two intercostal spaces on the concave side. With growth, additional intercalated riblets appear in all of the interspaces, though near the anterior end there are fewer intercalaries on the concave side than on the convex side. The intercalated or secondary ribs on the convex side ultimately assume equal importance with the primaries, whereas on the concave side, near the anterior end, the secondary ribs are slightly smaller than the principal ones. All of the ribs tend to diminish toward the anterior of the tube but do not lose their identity even around the peristome. Interspaces and ribs are smoothish, though transverse lines of growth may be seen with a lens. Many of the adult specimens bear two or more transverse constrictions, and these represent quiescent stages in growth. None of the shells in the collection is complete.

Dimensions.—Specimen G297a (broken away at both ends), length of cord between extremities 22.6 mm.; diameter at anterior end 3.2 mm. Specimen G297b (broken away at both ends), length 18.8 mm.; diameter at larger end 3 mm.

Localities.—Upper Mare formation at W-14, on hillside above west bank of Quebrada Mare Abajo. Ten specimens. Lower Mare formation, in small stream 100 meters west of Quebrada Mare Abajo. One specimen.

Comparisons.—*D. disparile* d'Orbigny is characterized by six primary ribs on the tip, *D. pilsbryi* Rehder by nine. The Miocene to Recent *D.*

antillarum d'Orbigny also has nine primary ribs on the tip, but the tip is more curved than on both *D. disparile* and on *D. pilsbryi.* The Recent *D. texasianum* Philippi is hexagonal in cross section on both the posterior and anterior ends, the latter area with an intercalated secondary rib in each of the interspaces. The Miocene *D. gabbi* Pilsbry and Sharp (1897, Acad. Nat. Sci. Philadelphia, Proc., vol. 49, pp. 470-471, pl. 10, figs. 6,7,13; pl. 11, figs. 1,2), from the Dominican Republic, is somewhat like *D. disparile,* but *D. gabbi* differs in shape, with the tip slightly curved and the greater part of the length nearly straight. On fragments of comparable size, *D. cartagenense* Pilsbry and Brown (1917, Acad. Nat. Sci. Philadelphia, Proc., vol. 69, pp. 37-38, pl. 5, fig. 10), from the middle Miocene of Colombia, has fewer ribs than the fossil *D. disparile* herein described from Venezuela.

Range and distribution.—The living *D. disparile* d'Orbigny is a shallow-water species ranging from Florida to Brazil. As a fossil, *D. disparile* has been reported from the Pliocene of South Carolina, Florida, and Trinidad, and from the upper Miocene of North Carolina.

Dentalium (Antalis) aff. **antillarum** d'Orbigny Pl. 17, figs. 3,4; Pl. 18, fig. 6

1842. *Dentalium Antillarum* d'Orbigny, [in] La Sagra, Hist. phys., polit. et nat. l'Ile de Cuba, vol. 2, Mollusques, p. 202, pl. 25, figs. 10-13.
1845. *Dentalium Antillarum* d'Orbigny, [in] La Sagra, Hist. Fís., Polít. y Nat. Isla de Cuba, pt. 2, vol. 5, Moluscos, p. 274.
1864. *Dentalium antillarum* d'Orbigny, Krebs, The West Indian Marine Shells, p. 91.
1867. *Dentalium antillarum* d'Orbigny, Guppy, Sci. Assoc. Trinidad, Proc., pt. 3, p. 160.
1878. *Dentalium Antillarum* Orbigny, Arango y Molina, Contribución a la Fauna Malacológica Cubana, p. 232.
1878. *Dentalium antillarum* Orbigny, Mörch, Catalogue of West-India Shells, p. 14, No. 950.
1889. *Dentalium antillarum* d'Orbigny, Simpson, Davenport Acad. Nat. Sci., Proc., vol. 5, p. 70.
1892. *Dentalium antillarum* Orbigny, Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 2, p. 211.
1894. *Dentalium antillarum* Orbigny, Dall, U. S. Nat. Mus., Proc., vol. 17 (1895), p. 686.
1897. *Dentalium* (*Antalis*) *antillarum* d'Orbigny, Pilsbry and Sharp, Man. Conch., vol. 17, p. 57, pl. 14, figs. 22-25 (also probably, *fide* Henderson, figs. 16-18, 20-21).
1901. *Dentalium* (*Antalis*) *antillarum* d'Orbigny, Dall and Simpson, U. S. Fish Com. Bull., vol. 20 for 1900, pt. 1, p. 456.
1920. *Dentalium* (*Antalis*) *antillarum* Orbigny, Henderson, U. S. Nat. Mus., Bull. 111, pp. 44-46, pl. 5, figs. 1-4, 6-8.
1922. *Dentalium* (*Antalis*) *antillarum* d'Orbigny, Maury, Bull. Amer. Paleont., vol. 9, No. 38, p. 35.
1934. *Dentalium antillarum* Orbigny, Johnson, Boston Soc. Nat. Hist., Proc., vol. 40, No. 1, p. 60.

1936. *Dentalium antillarum* Orbigny, Lermond, Check List of Florida Marine Shells, Gulfport, p. 24.
1937. *Dentalium antillarum* Orbigny, Smith, East Coast Marine Shells, p. 71, pl. 55, figs. 18a,b.
1942. *Dentalium antillarum* Orbigny ?, Jaume and Pérez Farfante, Soc. Cubana Hist. Nat. "Felipe Poey", Mem., vol. 16, No. 1, p. 38.
1954. *Dentalium* (*Dentale*) *antillarum* Orbigny, Abbott, American Seashells, p. 330.
1955. *Dentalium* (*Antalis*) *antillarum* d'Orbigny, Turner, Woods Hole Oceanogr. Inst., Contrib., No. 779, p. 311.
1958. *Dentalium* (*Dentale*) *antillarum* Orbigny, Abbott, Acad. Nat. Sci. Philadelphia, Mon. No. 11, p. 108, pl. 5g.
1959. *Dentalium antillarum* Orbigny, Nowell-Usticke, A Check List of the Marine Shells of St. Croix, p. 90.
1961. *Dentalium* (*Dentale*) *antillarum* Orbigny, Warmke and Abbott, Caribbean Seashells, p. 224, text fig. 34g.

The following description is from two worn and incomplete specimens.

Shell solid, slightly curved, moderately tapering, nonagonal-subcircular in cross section, with a nearly circular annulus throughout the length of the tube. Each of the subdued nine angles is represented by a longitudinal primary rib, and, at some distance below the tip, there is a secondary smaller rib in each of the interspaces; in all there are 18 ribs on the posterior portion of the tube below the tip (which is decollate). Crossing the interspaces and ribs are strong concentric striae, rather regularly spaced.

Dimensions.—Specimen S298a (a portion of the posterior, without tip), length 3.1 mm.; diameter at anterior end of tube 1.1 mm. Specimen S298b (a portion of the posterior, without tip), length 2 mm.; diameter at larger end of tube 1.4 mm.

Locality.—Playa Grande formation (Maiquetía member) at W-23, north flank of Punta Gorda anticline. Two incomplete specimens.

Remarks.—Although neither of the two specimens is complete nor well enough preserved for definitive comparison, affinity to the *D. antillarum* group is indicated. As the curvature of the tube appears to be slight, the Venezuelan shell is provisionally referred to *D. antillarum* rather than to the closly related *D. pseudohexagonum* Henderson (renamed *D. pilsbryi* by Rehder, 1942a, p. 69). According to Henderson (1920, p. 47), the shell of *D. pseudohexagonum* (=*D. pilsbryi* Rehder) is more regularly tapering and more regularly curved than is *D. antillarum.*

Range and distribution.—Pliocene to Recent. The living *D. antillarum* ranges from Florida to Barbados at depths of 1 to 38 fathoms. The fossil *D. antillarum* is reported (doubtfully) from Cuba in the Pleistocene, and from South Carolina and Trinidad in the Pliocene.

Dentalium (Antalis) species Pl. 17, fig. 5

The specimen is a section from the middle-anterior of an adult tube. The tube is scarcely curved, gently tapering, a little thicker posteriorly than anteriorly, and nearly circular in cross section at both ends. The sculpture consists of about 24 low longitudinal ribs tending to become obsolescent, but not disappearing entirely toward the anterior extremity. Every fourth rib is slightly higher and narrower than the others which are relatively broad and subequal in size. Some of the broader ribs bear fine longitudinal threads, and crossing the whole of the tube are worn but fairly prominent and regularly spaced transverse lirae. The shell is white, dense, and sturdy. Both extremities of the tube are missing.

Dimensions.—Specimen C300a, length 10.3 mm.; diameter at smaller end 2.1 mm.; diameter at larger end 2.5 mm

Locality.—Guaiguaza clay, near south shore of La Salina de Guaiguaza, six kilometers west of Puerto Cabello, State of Carabobo. One incomplete and worn specimen.

Remarks.—Without the posterior end it is not possible to place this species, but it is not dissimilar to the upper Miocene to Recent *D. disparile* d'Orbigny and to the Pliocene to Recent *D. antillarum* d'Orbigny.

Dentalium (Antalis?) species Pl. 16, fig. 2; Pl. 18, figs. 2,3

The Venezuelan specimen is a short segment representing the middle-anterior portion of the complete tube. The segment is slightly curved and moderately and regularly tapering. The cross section is circular, and the tube is thick, the thickness decreasing gradually anteriorward. The shell is dense, whitish, shiny but opaque, and although smooth on the surface, is girdled subsurficially by faint revolving lineations running around the tube a little obliquely. The indication is that the adult shell is relatively large and solid. Both ends of the tube are broken away and the characters are not known.

Dimensions.—Specimen I364a, length (both ends missing) 4.8 mm.; diameter at smaller end 1.25 mm.; diameter at larger end 1.7 mm.

Locality.—Lower Mare formation at W-13, on hillside above west bank of Quebrada Mare Abajo. One incomplete specimen.

Remarks.—With both ends of the tube missing it is not possible to compare this form with assurance, but what there is of it resembles both the west American *D.* (*Antalis*) *pretiosum* "Nuttall" Sowerby (1860, Thes. Conchyl., vol. 3, p. 95, pl. 225, fig. 7) and the east American *D.* (*Grap-*

tacme) *eboreum* Conrad (see Henderson, 1920, pp. 66-68, pl. 10, figs. 3-5,8,9; pl. 11, fig. 6). *D. pretiosum,* which ranges from Pliocene to Recent, and is living from Alaska to Baja California, is rather thick at the middle-anterior end, but the tube seems to be more rapidly tapering than the Venezuelan form. *D. eboreum,* which ranges from middle Miocene (?) to Recent, and is living from Cape Hatteras to South America, is similar in shape and texture but is thinner than the Venezuelan tube.

? **Dentalium** species indeterminate Pl. 17, fig. 6

The specimen illustrated is an incomplete, small, slightly curved, and gently tapering tube. The cross section at the larger end is circular. The shell is thin and subvitreous, the surface rendered drusy by minute calcite crystals. The character of the sculpture, if any, cannot be determined.

Dimensions.—Specimen O307a, length 3.6 mm.; diameter at larger end 0.75 mm.

Locality.—Playa Grande formation (Catia member) at W-22, on dip slope 100 meters west of Costa fault. One incomplete specimen.

Remarks.—More complete and better preserved examples are needed for a definitive diagnosis.

Fustiaria (Laevidentalium ?) venezuelana, new species
Pl. 17, fig. 7; Pl. 18, figs. 7,8

The single specimen is incomplete, and represents the middle-posterior part of the whole tube. The tube is worn, fairly thin but strong, gently curved, and moderately tapering, with a dense white unpolished shell. The cross section is ovate posteriorly, with the slightly narrower diameter of the annulus at the concave face; anteriorly the annulus is oval, and at both ends of the tube the greatest diameter is in the dorso-ventral plane. The surface of the shell is nearly smooth, but under a lens faint transverse growth lineations as well as nearly obsolescent longitudinal riblets may be seen. The tube is filled with fine calcareous sandstone producing an internal cast, and on the cast there are vague impressions of longitudinal ribs, the impressions a little clearer on the convex face of the cast. Both ends of the tube are broken away.

Dimensions.—Holotype (S302a), length (ends missing) 11.5 mm.; greatest diameter at larger end 2.2 mm.

Locality.—Playa Grande formation (Maiquetía member) at W-23, north flank of Punta Gorda anticline. One specimen, the holotype.

Remarks.—The generic and subgeneric classifications are uncertain as neither the anterior aperture nor the posterior aperture of the tube is present. At the smaller end of the type specimen the concave side of the tube is slightly subangular and cracked, possibly due to distortion from pressure.

Comparisons.—Subgenerically *F. venezuelana,* n. sp. seems to lie between *Laevidentalium* as represented by the Recent *F.* (*L.*) *liodon* Pilsbry and Sharp (1897, p. 107, pl. 21, figs. 37-39) and *Bathoxiphus* as represented by the Recent *F.* (*B.*) *didymum* Watson (see Watson, 1886, pp. 10-11, pl. 1, figs. 11,a-c) and *F.* (*B.*) *ensiculus* Jeffreys (see Jeffreys, 1882, Zool. Soc. London, Proc., p. 660, pl. 49, fig. 4). The subgenus *Laevidentalium,* however, lacks the longitudinal riblets weakly displayed on the Venezuelan form, and although such ribbing occurs on *Bathoxiphus* the species of that subgenus are considerably more compressed. The subgenus *Bathoxiphus* is differentiated from the subgenus *Compressidens* by the orientation of the long diameter of the annulus: the long diameter of *Bathoxiphus* is in alignment with the dorso-ventral plane, whereas on *Compressidens* it is normal to the dorso-ventral plane of the tube.

Fustiaria (Laevidentalium) perlongum ? (Dall)

Pl. 17, figs. 8-10; Pl. 18, figs. 9-11

1878. *Dentalium perlongum* Dall, Mus. Comp. Zool., Bull., vol. 5, No. 16, p. 61 (name only).
1881. *Dentalium perlongum* Dall, Mus. Comp. Zool., Bull., vol. 9, p. 36.
1888. *Dentalium perlongum* Dall, Agassiz, Three Cruises of the *Blake,* vol. 2, p. 76, fig. 284.
1889. *Dentalium perlongum* Dall, Mus. Comp. Zool., Bull., vol. 18, p. 419, pl. 27, fig. 6.
1889. *Dentalium perlongum* Dall, U. S. Nat. Mus., Bull. 37, p. 76, pl. 27, fig. 6.
1889. *Dentalium perlongum* Dall, U. S. Nat. Mus., Proc., vol. 12, p. 294.
1897. *Dentalium* (*Laevidentalium*) *perlongum* Dall, Pilsbry and Sharp, Man. Conch., vol. 17, p. 104, pl. 18, figs. 10-11.
1897. *Dentalium perlongum* Dall, Pilsbry and Sharp, Acad. Nat. Sci. Philadelphia, Proc., vol. 49, p. 472.
1903. *Dentalium perlongum* Dall, U. S. Nat. Mus., Bull. 37, p. 76, pl. 27, fig. 6.
1920. *Dentalium* (*Laevidentalium*) *perlongum* Dall, Henderson, U. S. Nat. Mus., Bull. 111, pp. 75-76, pl. 9, fig. 1.
1922. *Dentalium* (*Laevidentalium*) *perlongum* Dall, Maury, Bull. Amer. Paleont., vol. 9, No. 38, p. 38.
1934. *Dentalium* (*Laevidentalium*) *perlongum* Dall, Johnson, Boston Soc. Nat. Hist., Proc., vol. 40, No. 1, p. 61.
1937. *Dentalium perlongum* Dall, Smith, East Coast Marine Shells, p. 72, pl. 63, fig. 6.
1949. *Dentalium* (*Laevidentalium*) *perlongum* Dall, Lange de Morretes, Mus. Paranaense, Arq., vol. 7, art. 1, p. 54.
1952. *Dentalium* (*Laevidentalium*) *perlongum ?* Dall, Emerson, Smithsonian Mis. Collections, vol. 117, No. 6, p. 4.
1955. *Dentalium* (*Laevidentalium*) *perlongum* Dall, Turner, Woods Hole Oceanogr. Inst., Contrib., No. 779, p. 313.

Shell long and slender, slightly curved, fairly thin but strong, slowly and regularly increasing in diameter. The tip is subcircular, modified by a small notch which becomes a fine slit on the convex or ventral side of the tube. The cross section at the middle of the tube is circular; the cross section at the anterior end is not known as none of the specimens is complete. Surface somewhat shiny, wholly sculptureless.

Dimensions.—Specimen R299a, length (broken away anteriorly but with the posterior end intact) 13.7 mm.; diameter at larger end 1.8 mm. The whole specimen would be 30 mm. or more in length. Specimen I364b, length (posterior end with tip intact) 6 mm.; diameter at larger end 1 mm. Specimen T303a, length of fragment(both ends broken away) 4 mm.; diameter at larger end 1.1 mm.

Localities.—Playa Grande formation (Maiquetía member) at W-26, in Quebrada Las Bruscas approximately 125 meters upstream from junction with Quebrada Las Pailas. One incomplete specimen. Playa Grande formation (Maiquetía member) at W-4, Quebrada Las Pailas. One incomplete specimen. Lower Mare formation at W-13, on hillside above west bank of Quebrada Mare Abajo. One incomplete specimen. Upper Mare formation at W-14, on hillside above west bank of Quebrada Mare Abajo. One incomplete specimen, the identification tentative. Upper Mare formation, in stream 250 meters south-southwest of the mouth of Quebrada Las Pailas. One incomplete specimen, the identification tentative.

Remarks.—Compared with the corresponding posterior end of Recent specimens of *F. perlongum* from off Sarasota and Clearwater, Florida, the Venezuelan fossil specimen R299a matches perfectly, and I would unhesitatingly refer it to *F. perlongum* were it not for the fact that indisputable examples of that species are said to occur in deep water. Other mollusks associated with this fossil dentalid in Venezuela indicate that they were of shallow-water habitat. That the depth range of the Recent *F. perlongum* may be extended, however, to include shallow waters, is suggested by Henderson who reported some defective specimens of *F. perlongum* from 20 fathoms off S. Roque, Brazil, and some fragments from off Rio de La Plata in 11.5 fathoms which seemed to him referable to this species.

Range and distribution.—The living *F. perlongum* ranges from Cape Hatteras, North Carolina, through the Gulf of México and the Caribbean Sea to as far south as the Rio de La Plata in the Western Atlantic, at depths of 11.5 to 1,330 fathoms. If the identification is correct, this is the first notice of the occurrence of *F. perlongum* as a fossil in the Caribbean region.

Fustiaria (Laevidentalium) species Pl. 18, figs. 12-14

Known only by the tip and apical region. The shell is white, opaque, fairly thick, polished, and sculptureless, the adult possibly attaining a length of 15 to 20 mm. Cross section below apex circular. Projecting through the tip is a regrown inner tube, and this is entirely cut through by a slit which continues a short distance down the convex side of the main tube. The indication is that the curvature of the tube proper is slight.

Dimensions.—Specimen F670a, length (apical end of tube) 1.9 mm., diameter at larger end 0.6 mm.

Locality.—Upper Mare formation at W-14, on hillside above west bank of Quebrada Mare Abajo. One incomplete specimen, represented by an intact apex.

Remarks.—This is reminiscent of the lower and middle Miocene *Dentalium haytense* Gabb (see Woodring, 1925, Carnegie Inst. Washington. Publ. No. 366, pp. 202-203, pl. 27, figs. 18-20), from the Dominican Republic and Jamaica, and the Recent Caribbean *D. liodon* Pilsbry and Sharp (1897, Man. Conch., vol. 17, p. 107, pl. 21, figs. 37-39). However, it appears to be a thicker shell than both of those and is denser than *D. liodon.* The tube is also thicker than that of *F. perlongum* Dall.

SIPHONODENTALIIDAE

Cadulus (Gadila) bruscasensis, new species Pl. 18, figs. 15,16

Shell small, thin, subhyaline to subtranslucent, glossy, exceedingly slender, moderately curved, the maximum curvature occurring about one-third the distance down from the apex, the tube curved thereafter but slightly. The diameter increases evenly and gradually from the apex for a distance of about three-fourths the length of the tube but remains about the same or decreases imperceptibly therefrom toward the anterior end. The posterior tip is simple and truncate, and both the tip and equatorial area are nearly circular in cross section; the peristome of the type, however, is subcircular with the slightly longer diameter normal to the dorso-ventral plane. Just above the rim of the peristome, the tube is first hardly constricted and then slightly swollen, and there is a fine spiral line or two in the constricted area. The shell is virtually sculptureless, but subsurficially there are faint transverse growth markings running around the tube somewhat obliquely. Also there are bands of greater opacity alternating with the wider subhyaline zones.

Dimensions.—Holotype (R668a), length of cord between extremities 6.4 mm.; greatest diameter of peristome about 0.5 mm.

Type locality.—Playa Grande formation (Maiquetía member) at W-26, in Quebrada Las Bruscas approximately 125 meters upstream from junction with Quebrada Las Pailas. Seven specimens, all but the type broken.

Other localities.—Upper Mare formation at W-14, on hillside above west bank of Quebrada Mare Abajo. Two specimens.

Comparisons.—This species is similar to the Recent Western Atlantic *C. acus* Dall (1889, Mus. Comp. Zool., Bull., vol. 18, p. 432, pl. 27, fig. 11) and to the lower-middle Miocene *C. elegantissimus* Pilsbry and Sharp (1897, Acad. Nat. Sci. Philadelphia, Proc., vol. 49, p. 473, pl. 11, figs. 28-30) from the Dominican Republic. *C. acus* is characterized by numerour circular striae on the posterior third of the shell, whereas the lineations on *C. bruscasensis* are sparse and ephemeral. Also the tube is more swollen above the peristome on *C. acus* than on *C. bruscasensis*, n. sp. The peristome of *C. elegantissimus* is oval with the longer diameter in the dorso-ventral plane; on *C. bruscasensis* the longer diameter of the peristome is normal to the dorso-ventral plane. The type of *C. elegantissimus* (Academy of Natural Sciences of Philadelphia, No. 2885) is also more regularly and somewhat more prominently curved than *C. bruscasensis*, and the maximum diameter is nearer the anterior end than on *C. bruscasensis*.

Cadulus (Gadila) playagrandensis, new species Pl. 18, figs. 17,18

Shell small, moderately sturdy, arcuate with slight asymmetry, rather rapidly tapering from the apex to the equator, which is placed at about the anterior one-fourth, the diameter of the tube nearly constant therefrom to the anterior end. The convex or ventral face is subregularly curved to the equator, thence slightly curved to the anterior end; the concave or dorsal face is regularly curved to the equator, thence imperceptibly curved to the anterior end. The tip is simple and is nearly circular in cross section as are the equator and peristome. The anterior aperture or peristome is very slightly contracted for a short distance above the rim, and there is a fine circular line running around the tube at the posterior end of the contracted area. The shell substance is moderately dense, and a few specimens are white and opaque. Superficially the shell is sculptureless and somewhat shiny, but subsurficially the tube is girdled by numerous narrow growth bands. There are also faint circular zones of alternating density of the shell.

Dimensions.—Holotype (Q669a), length of cord between extremities 3.5 mm.; diameter at anterior aperture 0.35 mm. This is the only complete example; all of the other specimens are broken.

Type locality.—Playa Grande formation (Maiquetía member) at W-4, Quebrada Las Pailas. Thirty-seven specimens.

Other localities.—Playa Grande formation (Maiquetía member) at W-3, in Quebrada Las Pailas, south side of Mare Abajo fault near its intersection with the Bruscas fault. One incomplete specimen. Playa Grande formation (Maiquetía member) at W-26, in Quebrada Las Bruscas approximately 125 meters upstream from junction with Quebrada Las Pailas. Two specimens. Upper Mare formation at W-14, on hillside above west bank of Quebrada Mare Abajo. Four specimens.

Comparisons.—This species is close to the Recent Western Atlantic *C. acus* Dall and to the lower-middle Miocene *C. phenax* Pilsbry and Sharp (1897, pp. 472-473, pl. 11, figs. 23-24) from the Dominican Republic. However, the Venezuelan fossil may be distinguished from *C. acus* by its shorter and somewhat more rapidly tapering tube and from *C. phenax* (type at Academy of Natural Sciences of Philadelphia, No. 2883) by its more slender tube which lacks the slight swelling just above the peristome. *C. playagrandensis*, n. sp. is also similar to the Recent Caribbean *C. dominguensis* (d'Orbigny) (1842, [in] La Sagra, Hist. phys., polit. et nat. l'Ile de Cuba, vol. 2, Mollusques, p. 201, Atlas, pl. 25, figs. 7-9), but the aperture of *C. dominguensis* is oval whereas that of the Venezuelan fossil is nearly circular. From *C. bruscasensis*, n. sp., described in this work, *C. playagrandensis* is differentiated by its denser shell, by the somewhat more pronounced taper of the tube, and by its more circular aperture.

Cadulus (Polyschides) quadridentatus (Dall)

Pl. 17, figs. 11,12; Pl. 18, figs. 19,20

1881. *Siphonodentalium quadridentatum* Dall, Mus. Comp. Zool., Bull., vol. 9, p. 36.

1885. *Cadulus incisus* Bush, Connecticut Acad. Arts and Sci., Trans., vol. 8, p. 471, pl. 45, fig. 20.

1889. *Cadulus quadridentatus* (Dall), Mus. Comp. Zool., Bull., vol. 18, p. 428, pl. 27, fig. 5.

1889. *Cadulus quadridentatus* (Dall), U. S. Nat. Mus., Bull. 37, p. 76, pl. 27, fig. 5.

1889. *Cadulus quadridentatus* (Dall), U. S. Nat. Mus., Proc., vol. 12, p. 295.
1892. *Cadulus quadridentatus* (Dall), Wagner Free Inst. Sci., Trans., vol. 3, p. 445.
1898. *Cadulus* (*Polyschides*) *tetraschistus quadridentatus* (Dall), Pilsbry and Sharp, Man. Conch., vol. 17, p. 149, pl. 23, fig. 7.
1898. *Cadulus* (*Polyschides*) *tetraschistus incisus* Bush, Pilsbry and Sharp, Man. Conch., vol. 17, p. 150, pl. 25, fig. 65.
1903. *Cadulus quadridentatus* (Dall), U. S. Nat. Mus., Bull. 37, p. 76, pl. 41, fig. 20.
1920. *Cadulus* (*Polyschides*) *quadridentatus* (Dall), Henderson, U. S. Nat. Mus., Bull. 111, pp. 4,12,18,97-100, pl. 17, figs. 2-3.
1922. *Cadulus* (*Polyschides*) *quadridentatus* (Dall), Maury, Bull. Amer. Paleont., vol. 9, No. 38, p. 40.
1930. *Cadulus* aff. *C.* (*Polyschides*) *quadridentatus* (Dall), Mansfield, Florida State Geol. Sur., Bull. No. 3, pp. 141-142.
1934. *Cadulus* (*Polyschides*) *quadridentatus* (Dall), Johnson, Boston Soc. Nat. Hist., Proc., vol. 40, No. 1, p. 64.
1937. *Cadulus quadridentatus* (Dall), Smith, East Coast Marine Shells, p. 73, pl. 63, fig. 5; pl. 65, fig. 20.
1949. *Cadulus* (*Polyschides*) *quadridentatus* (Dall), Lange de Morretes, Mus. Paranaense, Arq., vol. 7, art. 1, p. 52.
1953. *Cadulus* (*Polyschides*) *quadridentatus* (Dall), Olsson and Harbison, Acad. Nat. Sci. Philadelphia, Mon. No. 8, pp. 156-157.
1954. *Cadulus* (*Polyschides*) *quadridentatus* (Dall), Abbott, American Seashells, p. 328, fig. 69b.
1955. *Cadulus* (*Polyschides*) *quadridentatus* (Dall), Turner, Woods Hole Oceanogr. Inst., Contrib., No. 779, pp. 315,319.
1955. *Cadulus quadridentatus* (Dall), Perry and Schwengel, Marine Shells of the Western Coast of Florida, p. 101, pl. 45, figs. 315a,b.
1958. *Cadulus* (*Polyschides*) *quadridentatus* (Dall), Abbott, Acad. Nat. Sci. Philadelphia, Mon. No. 11, p. 108.
1959. *Cadulus quadridentatus* (Dall), Nowell-Usticke, A Check List of the Marine Shells of St. Croix, p. 90.
1961. *Cadulus* (*Polyschides*) *quadridentatus* (Dall), Warmke and Abbott, Caribbean Seashells, p. 220, text fig. 34c.

Shell small, thin, moderately slender, virtually sculptureless. Tube gradually and regularly increasing in diameter to about the anterior third, decreasing slowly therefrom toward the anterior aperture. There is no local swelling, and the exact position of the equator is not defined. The curvature of the tube is slight to moderate, the curve a little more pronounced on the posterior third. The convex side is evenly curved, with little modification from the equatorial zone to the extremities; the concave side is moderately and evenly arched in the posterior third, but the remainder of the length is nearly straight. Cross sections of the tube at the apex, at the middle, and near the anterior aperture are nearly circular. Apical orifice with four relatively deep notches creating as many lobes. The lobe on the convex side is the highest and is subangular at the crest; the lobe on the concave side is the lowest and is horizontally truncate at its crest; the lateral lobes are subequal and triangular. Anterior aperture not seen. The shell of some specimens is straw-colored, dense, and dull; the shell of others is white, opaque, and somewhat shiny.

Dimensions.—Specimen I365a, length of incomplete tube (posterior end with tip intact) 3.5 mm.; diameter at larger end 0.8 mm. Specimen H299a, length of incomplete tube (posterior end with tip intact) 2.3 mm.; diameter at larger end 0.7 mm. Specimen S302b, length of apical end (tip intact) 2 mm.; diameter at larger end 0.8 mm.

Localities.—Lower Mare formation at W-13, on hillside above west bank of Quebrada Mare Abajo. One incomplete specimen. Mare formation at W-25, south flank of Punta Gorda anticline. Three incomplete specimens. Playa Grande formation (Maiquetía member) at W-23, north flank of Punta Gorda anticline. Two incomplete specimens, tips only.

Remarks.—Some Recent tubes of *C. quadridentatus* may be more hyaline and slightly wider at the equator than the Venezuelan fossils here described, but the latter are otherwise identical. Dentalid shells, which are normally hyaline when fresh, are often opaque and dense in old, worn, or fossil specimens.

Range and distribution.—Upper Miocene (?) and Pliocene of Florida; Recent from Cape Hatteras, North Carolina, to Rio de La Plata, South America, at depths of 2-52 fathoms. *C. quadridentatus* (Dall) has not been previously recorded as a fossil from South America.

Cadulus (Polyschides) tetraschistus? (Watson) Pl. 17, fig. 13; Pl. 18, fig. 21

1879. *Siphodentalium tetraschistum* Watson, Linnean Soc. London Jour., vol. 14, p. 521, No. 4.
1886. *Siphodentalium tetraschistum* Watson, Voyage H.M.S. Challenger, Zoology, vol. 15, pt. 2, pp. 15-16, pl. 15, figs. 8, a-d.
1898. *Cadulus* (*Polyschides*) *tetraschistus* (Watson), Pilsbry and Sharp, Man. Conch., vol. 17, p. 148, pl. 23, fig. 1.
1920. *Cadulus* (*Polyschides*) *tetrachistus* [*sic*] (Watson), Henderson, U. S. Nat. Mus., Bull. 111, p. 97, pl. 17, fig. 1.
1949. *Cadulus* (*Polyschides*) *tetraschistus* (Watson), Lange de Morretes, Mus. Paranaense, Arq., vol. 7, art. 1, p. 52.
1955. *Cadulus* (*Polyschides*) *tetraschistus* (Watson), Turner, Woods Hole Oceanogr. Inst., Contrib., No. 779, p. 314.
1962. *Cadulus* (*Polyschides*) *tetraschistus* (Watson), Emerson, Jour. Paleont., vol. 36, No. 3, pp. 479-480, pl. 80, fig. 4.

The single specimen is an internal cast made up of fine calcareous sandstone, the cast coated posteriorly, however, by a thin drusy layer of shell The tube is slightly curved, with its greatest diameter 7 mm. from the apex and with the equatorial region gently swollen. The convex side of the tube is evenly and gently arched from the area of maximum caliber to the posterior end; the concave face of the tube is hardly curved posteriorly and nearly straight anteriorly, and from about the middle to the anterior end the concave face is slightly flattened. Posterior orifice rounded, beveled down, but with an undulatory rim suggesting the presence of lobes on the unworn shell. The anterior aperture is broken away, but near the aperture the cross section is subcircular, with the diameter of the tube a trifle longer normal to the dorso-ventral plane. There are three disconnected slits on the concave face but these, I believe, are fortuitous and due to corrosion rather than to morphology. The anterior end of the tube is slightly contracted. There are no clearly visible details of sculpture, but under the microscope and in certain light some faint evanescent longitudinal striae may be discerned.

Dimensions.—Specimen O308a, length 8.5 mm.; diameter at larger end 1.6 mm.; diameter of posterior orifice 0.8 mm.

Locality.—Playa Grande formation (Catia member) at W-22, on dip slope 100 meters west of Costa fault. One incomplete and worn specimen.

Remarks.—Because of poor preservation and lack of individuals the identity of the fossil is uncertain. Nevertheless the resemblance to *C. tetraschistus* is striking even to the remote suggestion of the evanescent longitudinal scupture noted by Watson.

Range and distribution.—*Cadulus tetraschistus* (Watson) is a shallow-water species ranging from Brazil to Argentina in depths of 7 to 25 fathoms. The validity of its occurrence as a fossil in Venezuela, as herein suggested, requires verification.

? **Cadulus** species indeterminate Pl. 17, fig. 14

Illustrated, for the sake of completeness, is the internal cast of a somewhat arcuate, sausage-like form with the greatest diameter nearly midway between the extremities, the tube tapering gently away from the slightly swollen equatorial area. The convex side is asymmetrically arched, but the concave side is nearly straight for much of the length though somewhat curved toward one of the ends. The tube is rounded in cross section at the middle and near the extremities. Both ends are blunt and worn down rendering it uncertain as to which is anterior and which posterior. The cast is composed of tan fine-grained calcareous sandstone.

Dimensions.—Specimen O309a, length 4.7 mm.; max. diameter 1.05 mm.

Locality.—Playa Grande formation (Catia member) at W-22, on dip slope 100 meters west of Costa fault.

Remarks.—As the shelly material is missing there is not much that can be done taxonomically with this form.

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PLATES

EXPLANATION OF PLATE 16

Figure Page

1. **Dentalium (Dentalium)** cf. **texasianum rioense** Henderson 118

Specimen C301a, 26878 PRI. Length 3.8 mm.; diameter at larger end 0.8 mm. Guaiguaza clay. See Pl. 18, fig. 1.

2. **Dentalium (Antalis?)** species 126

Specimen I364a, 26879 PRI. Length 4.8 mm.; diameter at smaller end 1.25 mm.; diameter at larger end 1.7 mm. Lower Mare formation. See Pl. 18, figs. 2,3.

3-6. **Dentalium (Graptacme) semistriolatum** Guilding 119

Figs. 3-5, specimen I366a, 26880 PRI. Length 8.3 mm., diameter at larger end 1.25 mm. Fig. 3, view of side; fig. 4, enlarged view of same side; fig. 5, view of opposite side, showing slit. Lower Mare formation. Fig. 6, specimen T304a, 26881 PRI. Length 3.6 mm.; diameter at larger end 0.9 mm. Upper Mare formation.

7, 8. **Dentalium (Antalis) disparile** d'Orbigny 122

Specimen G297a, 26882 PRI. Length of cord between extremities 22.6 mm.; diameter at larger end 3.2 mm. Fig. 7, view of side; fig. 8, enlarged view of same side. Upper Mare formation. See Pl. 18, figs. 4,5.

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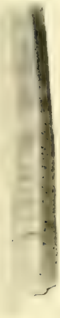

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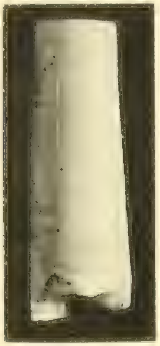

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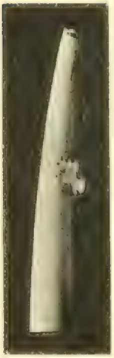

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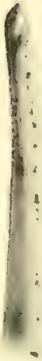

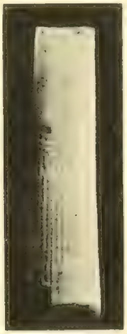

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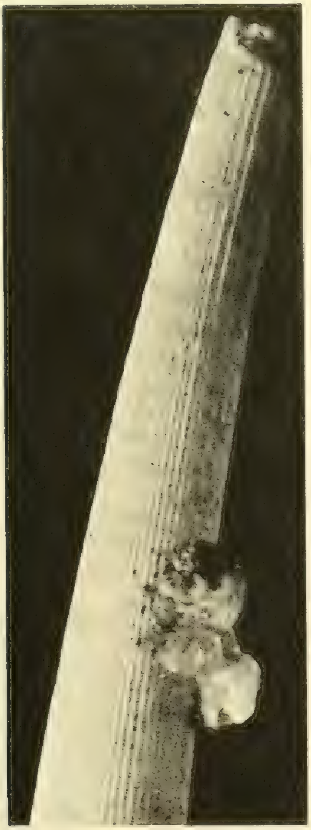

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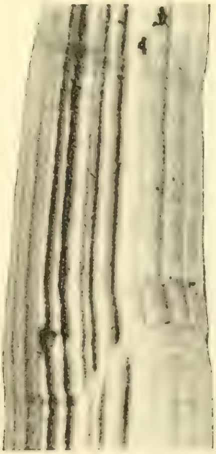

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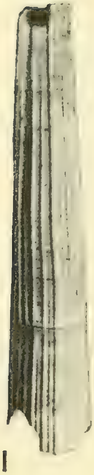
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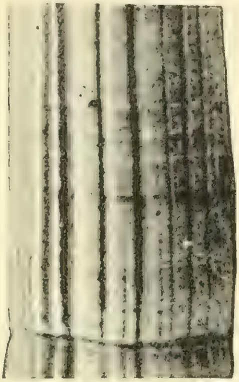
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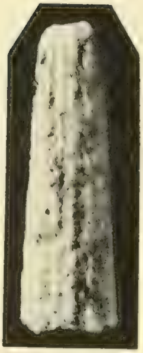
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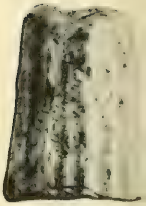
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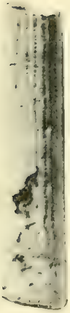
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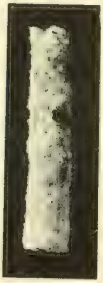
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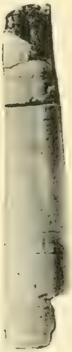
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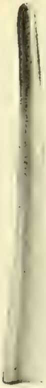
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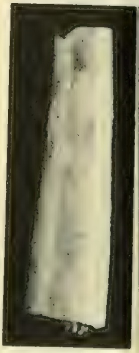
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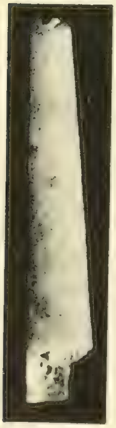
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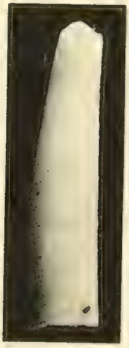
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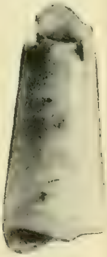
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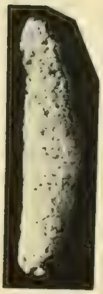
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EXPLANATION OF PLATE 17

Figure Page

1, 2. **Dentalium (Antalis) disparile** d'Orbigny 122

Specimen G297b, 26883 PRI. Length 18.8 mm.; diameter at larger end 3 mm. Upper Mare formation.

3, 4. **Dentalium (Antalis)** aff. **antillarum** d'Orbigny............................ 124

Fig. 3, specimen S298a, 26884 PRI. Length 3.1 mm.; diameter at larger end 1.1 mm. Fig. 4, specimen S298b, 26885 PRI. Length 2 mm.; diameter at larger end 1.4 mm. Playa Grande formation (Maiquetía member). See Pl. 18, fig. 6.

5. **Dentalium (Antalis)**, species 126

Specimen C300a, 26886 PRI. Length 10.3 mm.; diameter at smaller end 2.1 mm.; diameter at larger end 2.5 mm. Guaiguaza clay.

6. **Dentalium**, species indeterminate 127

Specimen O307a, 26887 PRI. Length 3.6 mm.; diameter at larger end 0.75 mm. Playa Grande formation (Catia member).

7. **Fustiaria (Laevidentalium?) venezuelana** Weisbord, n. sp......... 127

Holotype (S302a), 26888 PRI. Length 11.5 mm.; greatest diameter at larger end 2.2 mm. Side view. Playa Grande formation (Maiquetía member). See Pl. 18, figs. 7,8.

8-10. **Fustiaria (Laevidentalium) perlongum** ? (Dall) 128

Fig. 8, specimen R299a, 26889 PRI. Length 13.7 mm.; diameter at larger end 1.8 mm. Playa Grande formation (Maiquetía member). See Pl. 18, figs. 9,10. Fig. 9, specimen T303a, 26890 PRI. Length 4 mm.; diameter at larger end 1.1 mm. Upper Mare formation. Fig. 10, specimen I364b, 26891 PRI. length 6 mm.; diameter at larger end 1 mm. View of concave side. Lower Mare formation. See Pl. 18, fig. 11.

11, 12. **Cadulus (Polyschides) quadridentatus** (Dall) 132

Fig. 11, specimen I365a, 26892 PRI. Length 3.5 mm.; diameter at larger end 0.8 mm. Lower Mare formation. See Pl. 18, fig. 19. Fig. 12, specimen S302b, 26893 PRI. Length (apical portion) 2 mm.; diameter at larger end 0.8 mm. Playa Grande formation (Maiquetía member).

13. **Cadulus (Polyschides) tetraschistus** ? (Watson) 134

Specimen O308a, 26894 PRI. Length 8.5 mm.; diameter at larger end 1.6 mm.; diameter at smaller end 0.8 mm. View of concave side. Playa Grande formation (Catia member). See Pl. 18, fig. 21.

14. **Cadulus** ?, species indeterminate 135

Specimen O309a, 26895 PRI. Length 4.7 mm.; equatorial diameter 1.05 mm. Playa Grande formation (Catia member).

Explanation of Plate 18

Figure Page

1. **Dentalium (Dentalium)** cf. **texasianum rioense** Henderson.... 118
Specimen C301a, 26878 PRI. Cross section at smaller end, with tip up and convex side of tube toward observer. Guaiguaza clay. See Pl. 16, fig. 1.

2, 3. **Dentalium (Antalis?)** species... 126
Specimen I364a, 26879 PRI. Fig. 2, cross section at smaller end, with tip up and convex side of tube toward observer; fig. 3, cross section at larger end, with tip down and convex side of tube toward observer. Lower Mare formation. See Pl. 16, fig. 2.

4, 5. **Dentalium (Antalis) disparile** d'Orbigny 122
Specimen G297a, 26882 PRI. Fig. 4, cross section at smaller end, with tip up and convex side of tube toward observer; fig. 5, cross section at larger end, with tip down and convex side of tube toward observer. Upper Mare formation. See Pl. 16, figs. 7,8.

6. **Dentalium (Antalis)** aff. **antillarum** d'Orbigny 124
Specimen S298b, 26885 PRI. Cross section at larger end, with tip down and convex side of tube toward observer. Playa Grande formation (Maiquetía member). See Pl. 17, fig. 4.

7, 8. **Fustiaria (Laevidentalium?) venezuelana** Weisbord, n. sp. 127
Holotype (S302a), 26888 PRI. Fig. 7, cross section at smaller end, with tip up and convex side of tube toward observer; fig. 8, cross section at larger end, with tip down convex side of tube toward observer. Playa Grande formation (Maiquetía member). See Pl. 17, fig. 7.

9-11. **Fustiaria (Laevidentalium) perlongum** ? (Dall)............................ 128
Figs. 9,10, specimen R299a, 26889 PRI. Fig. 9, tip and view of slit on convex side of tube; fig. 10, cross section at larger end. Playa Grande formation (Maiquetía member). See Pl. 17, fig. 8. Fig. 11, specimen I364b, 26891 PRI. Convex side showing tip and slit. Lower Mare formation. See Pl. 17, fig. 10.

12-14. **Fustiaria (Laevidentalium)** species 130
Specimen F670a, 26896 PRI. Length (apical end of tube) 1.9 mm.; diameter at larger end 0.6 mm. Fig. 12, convex side and view of tip; fig. 13, concave side and view of tip; fig. 14, cross section of tube at larger end. Lower Mare formation.

15, 16. **Cadulus (Gadila) bruscasensis** Weisbord, n. sp. 130
Holotype R668a, 26897 PRI. Length of cord between extremities 6.4 mm.; greatest diameter at anterior aperture 0.5 mm. Fig. 15, view of side; fig. 16, cross section at peristome with tip down and convex side of tube toward observer. Playa Grande formation (Maiquetía member).

17, 18. **Cadulus (Gadila) playagrandensis** Weisbord, n. sp. 131
Holotype Q669a, 26898 PRI. Length of cord between extremities 3.5 mm.; diameter at anterior aperture 0.35 mm. Fig. 17, view of side; fig. 18, cross section at peristome with tip down and convex side of tube toward observer. Playa Grande formation (Maiquetía member).

19, 20. **Cadulus (Polyschides) quadridentatus** (Dall) 132
Fig. 19, specimen I365a, 26892 PRI. View of tip with concave side of tube toward observer and leaning back. Lower Mare formation. See Pl. 17, fig. 11. Fig. 20, specimen H299a, 26899 PRI. Length 2.3 mm.; diameter at larger end 0.7 mm. Side view. Mare formation.

21. **Cadulus (Polyschides) tetraschistus** ? (Watson) 134
Specimen O308a, 26894 PRI. View of side, enlarged. Playa Grande formation (Catia member). See Pl. 17, fig. 13.

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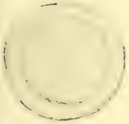
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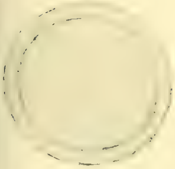
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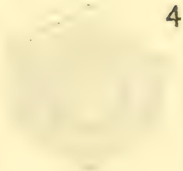
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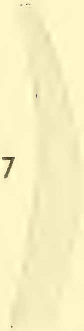
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PART 2. SOME SERPULID POLYCHAETES FROM CABO BLANCO, VENEZUELA[1]

ABSTRACT

Seven species in the family Serpulidae are described, compared, and illustrated. Four of the serpulids are fossil, one is both fossil and Recent, and two are Recent. Four of the fossil species are believed to be new, and occur in the Playa Grande and Mare formations of Pliocene age. The fossil and living species—*Pomatoceros minutus* Rioja—occurs in the Mare formation (Pliocene) and Abisinia formation (Pleistocene), and is found attached to various mollusk shells living today in the waters along the coast. The two other Recent species are identified (from the character of the tube only) as *Hydroides* aff. *bispinosa* Bush and *Eupomatus* cf. *dianthus* (Verrill).

INTRODUCTION

This is the fourth of a series of papers dealing with the fossil and Recent marine invertebrates collected by the writer in 1955 and 1956 in northern Venezuela. Earlier monographs (see Weisbord 1962, 1964, and Pt. 1 of this paper) dealt, respectively, with the Gastropoda, the Pelecypoda, and the Scaphopoda. In the present work seven tubicolous species in the family Serpulidae, class Polychaetia are described, compared, and illustrated. Included in this number are five species formerly classified by me as vermetids in the class Gastropoda but which are now regarded as serpulids in the class Polychaetia of the phylum Annelida. The fossil serpulids were collected from formations of the Cabo Blanco group exposed in the hills fronting the Caribbean Sea, and the empty Recent tubes were collected from dead mollusk shells (to which they were attached) lying on the nearby beach. The Cabo Blanco area is situated at the coast in the Distrito Federal some 19 kilometers or so by road northwest of Caracas, the capital city of Venezuela.

The types and specimens figured in this work are deposited with the Paleontological Research Institution, Ithaca, New York. Duplicates are in the collection of the Department of Geology, Florida State University, Tallahassee, Florida.

ACKNOWLEDGMENTS

For their advice and counsel, given through correspondence or during my visits with them, I am greatly indebted to Olga Hartman of the Allan Hancock Foundation; to Benjamin F. Howell of Princeton University; to

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[1] The writer wishes to express his appreciation to the National Science Foundation for its support of this study.

Meredith Jones of the American Museum of Natural History; to A. Myra Keen of Stanford University; to Joseph P. E. Morrison and Marian H. Pettibone of the U. S. National Museum; and to Walter J. Schmidt of Vienna, the author of a number of important papers on fossil serpulids. I also wish to express my appreciation to the personnel of the Academy of Natural Sciences of Philadelphia for allowing me free access to the Academy's superb library which contains most of the publications listed in the Bibliography of the present work.

I am particularly grateful to Dr. Myra Keen for calling my attention to the possibility that some of the forms referred by me to the Vermetidae in my work on the Gastropoda (Weisbord 1962) might belong to the family Serpulidae, and to Dr. Benjamin F. Howell for his comments and analysis of the forms in question.

The drawings in the present paper were made by Dorothy P. Janson, artist with the Florida Geological Survey. The photography of the shells was done by Hal F. Riehle and Werner Vagt.

LOCALITIES

The localities at which the serpulids were collected and the formations in which they occur are listed below. Each locality is designated by a letter, and the appropriate letter is prefixed to each number. All of the localities are shown on the geologic map accompanying the writer's paper (Weisbord 1957) titled "Notes on the geology of the Cabo Blanco area, Venezuela." On the 1957 map, field stations are designated by the letter W, and some of the localities refer also to those stations.

A. Beach, at Playa Grande Yachting Club, Distrito Federal. Recent.
B. Beach, southeast of Higuerote, State of Miranda. Recent.
D. Eastern edge of Playa Grande village, at W-30. Abisinia formation. Pleistocene.
F. Hillside above west bank of Quebrada Mare Abajo, at W-14. Upper Mare formation. Pliocene.
G. Hillside above west bank of Quebrada Mare Abajo, near W-14. Mare formation. Pliocene.
H. Fifteen meters south of axis of Punta Gorda anticline, at W-25. Mare formation. Pliocene.
I. Hillside above west bank of Quebrada Mare Abajo, at W-13. Lower Mare formation. Pliocene.

J. Small stream 100 meters west of Quebrada Mare Abajo and 125 meters west-southwest of the intersection of Quebrada Mare Abajo and the coast road. Lower Mare formation. Pliocene.

M. South side of Playa Grande road 40 meters southeast of its intersection with the Playa Grande Yachting Club road. Playa Grande formation (Catia member). Pliocene.

O. Dip slope 100 meters west of Costa fault and 130 meters south of shoreline, at W-22. Playa Grande formation (Catia member). Pliocene.

S. Near *Lithothamnium* bioherm at W-25, north flank of Punta Gorda anticline. Playa Grande formation (Maiquetía member). Pliocene.

SERPULIDS COLLECTED IN THE CABO BLANCO AREA

The serpulids collected in the Cabo Blanco area, and the formations in which they occur are listed below. Formational names are abbreviated thusly: Re=Recent; Ab=Abisinia formation; Ma=Mare formation; PGm=Playa Grande formation (Maiquetía member); and PGc=Playa Grande formation (Catia member).

Species	*Formation*
"Serpula" catiana Weisbord, n. sp.	PGc
"Serpula" incompta (Weisbord)	Ma; PGm
Hydroides aff. bispinosa Bush	Re
Eupomatus cf. dianthus (Verrill)	Re
Pomatoceros minutus Rioja	Re; Ab; Ma
Protula ? playagrandensis Weisbord, n. n.	PGc
Spirorbis (Laeospira) venezuelensis Weisbord, n. sp	Ma; PGc

RESUME OF STRATIGRAPHY

The fossil tubes described in this work occur in one formation or the other of the Cabo Blanco group, the standard section of which is displayed in the Cabo Blanco area. The formations constituting the group (see Rivero, 1956, and Weisbord, 1957, 1962, 1964) are, from bottom to top, the following:

Las Pailas formation. An unfossiliferous sequence of coarse and fine clastics of presumed mid-Tertiary age, with a maximum thickness of at least 375 meters (1230 feet). An angular unconformity separates the Las Pailas from the overlying Playa Grande formation.

Playa Grande formation. This is divided into two members, the *Catia* with a maximum measured thickness of 235 meters (770 feet) below, and the *Maiquetía* with a maximum thickness of 26 meters (85 feet) above. Both members are made up of a diversified assemblage of rocks which are moderately fossiliferous, the mollusks indicating that the age is Pliocene. Locally there is a pronounced unconformity between the Playa Grande formation and the overlying Mare formation, but, to judge from the occurrence of many of the same species in both formations, the time lapse in deposition was of short duration.

Mare formation. A highly fossiliferous unit with a maximum thickness of 18 meters (60 feet). The age, determined from the Mollusca, is believed to be Pliocene.

Abisinia formation. Terrace deposits, not over 12 meters (40 feet) thick in any one terrace. Locally the formation contains marine fossils which are Pleistocene in age.

ANALYSIS OF THE INVERTEBRATES OF THE CABO BLANCO GROUP

In the following tables all of the invertebrates of the Cabo Blanco group thus far studied are enumerated by class to show the number and per cent of fossil species in a given formation that have survived to Recent time. As there is a judgment factor involved in determining whether a fossil species is the same as, or distinct from its Recent analogue, the number of fossil species that are also living is presented in the tables as a minimum-to-maximum figure. Applying Lyell's percentage method of subdividing the Cenozoic into epochs for the classes Gastropoda[2], Pelecypoda, and Scaphopoda in the phylum Mollusca and for the class Polychaetia in the phylum Annelida, the Abisinia formation seems rather definitely to be Pleistocene in age, and the Mare and Playa Grande formations to be Pliocene in age.

[2] Five species formerly considered to be gastropods are now regarded as polychaetes.

TABLE 1. INVERTEBRATES OF THE ABISINIA FORMATION

Class	*Total number of species*	*Number of Recent species*	*Per Cent of Recent species*
Gastropoda	34	26-31	76-88
Pelecypoda	18	15-16	83-90
Scaphopoda	—	—	—
Polychaetia	1	1	100
Total	53	42-50	80-94

TABLE 2. INVERTEBRATES OF THE MARE FORMATION

Class	*Total number of species*	*Number of Recent species*	*Per Cent of Recent species*
Gastropoda	142	23-48	16-34
Pelecypoda	82	32-38	39-46
Scaphopoda	8	4	50
Polychaetia	3	1	33
Total	235	60-91	26-39

TABLE 3. INVERTEBRATES OF THE PLAYA GRANDE FORMATION
(Maiquetía member)

Class	*Total number of species*	*Number of Recent species*	*Per Cent of Recent species*
Gastropoda	81	7-22	9-28
Pelecypoda	53	23-31	43-58
Scaphopoda	6	3	50
Polychaetia	1	0	—
Total	141	33-56	23-40

TABLE 4. INVERTEBRATES OF THE PLAYA GRANDE FORMATION
(Catia member)

Class	*Total number of species*	*Number of Recent species*	*Per Cent of Recent species*
Gastropoda	3	0-1	0-33
Pelecypoda	26	8-10	31-40
Scaphopoda	2	1	50
Polychaetia	3	0-1	0-33
Total	34	8-13	24-40

VERMETID GASTROPODS COMPARED WITH SERPULID POLYCHAETES

As it is often difficult to differentiate tubes belonging to the family Vermetidae (class Gastropoda, phylum Mollusca) from tubes in the family Serpulidae (class Polychaetia, phylum Annelida), it may not be amiss to call attention to certain characters by which the tubes of each group may be classified. The soft parts of the animal, or the operculum, when found in the tube, are distinctive enough to afford ready discrimination, but the paleontologist or conchologist dealing without soft parts and frequently with fragmental, incomplete, or poorly preserved tubes, may be hard-pressed to distinguish vermetids from serpulids. The superficial similarities of certain tubes of Vermetidae and Serpulidae are well known. Both may be ornamented similarly on the exterior; both may build irregularly coiled and contorted tubes; both may occur singly or in clusters; both may be attached to dissimilar substrates; both may produce an operculum; and both vermetid and serpulid tubes are predominantly calcareous in composition. Nevertheless there are certain characters of the tube that are indicative of its taxonomic position, and these criteria, which have been discussed by Rovereto (1898), Wrigley (1950b, 1951), Schmidt (1951b, 1955a), Keen (1961), and Howell (1962), among others, are set forth below.

1. The Shell

The adult vermetid shell is calcareous, three-layered, and generally of substantial thickness. In fossilization all three layers are said to become aragonitic, aragonite being the orthorhombic form of calcium carbonate. The adult serpulid shell is also calcareous, but is made up of only two layers, the inner one having a composition like aragonite, the outer layer a composition like calcite which is the hexagonal-rhombohedral form of calcium carbonate. After fossilization, the two layers of the serpulids become distinct by the dissimilarity of their original substance. Recent studies on the carbonate content of living and fossil mollusk shells indicate that there is a complex aragonite-calcite relationship, but according to Wrigley (1950b) the outer layer of fossil vermetids behaves mineralogically like aragonite, whereas the outer layer of serpulids "has the appearance" of calcite.

2. The Annulus

The annulus, or bore of tubicolous shells is enclosed by the inner wall. In well-preserved specimens the wall of the annulus is generally shiny or lustrous in the vermetids, but matt or dull in the serpulids. In some genera of the Vermetidae the annulus may be sealed off by septa, or the wall girdled by spiral laminae or shelves encircling the columella. There are no such septa or laminae in the Serpulidae, and the annulus is always smooth.

3. The Outer Layer

In many serpulid tubes, especially in those where the outer layer is laminated, there is a marked eccentricity in cross section, the eccentricity caused by one or more of the laminae not completely encircling the inner layer of the tube. Also, in some serpulid tubes the outer layer is vesicular or perforated, but the vesicles or cells do not pierce the wall of the annulus. Eccentricity of the layering and the confined cellular structure of the outer layer have not been observed in tubes of the Vermetidae. In longitudinal section, the outer layer of the serpulid tube is made up of a series of oblique or parabolic laminae with the crests pointing forward (Schmidt, 1955a, pl. 1, figs. 1,3,5). The outer layer of the vermetids, however, is prismatic in structure, with the structural grain oriented normal to the wall.

4. The Nucleus or Apex

The apex of the vermetid tube is coiled into true whorls, and of those, the initial or nepionic whorl is closed. The apex or initial stage of the serpulid tube is uncoiled and open-ended.

5. The Operculum

Certain genera of both the Vermetidae and Serpulidae are provided with an operculum or stopper which is attached to the fleshy part of the animal and can be retracted to fit into the aperture at the anterior end of the tube. The operculum of vermetids is attached to the "foot" of the animal, and is made up of a spirally wound plate of chitin which may be flat, thickened at the center, or saucer-shaped. The operculum of the Serpulidae is attached to a pedicle or stalk protruding from the thorax. In living species of the Serpulidae the opercula are horny or leathery with, occasionally, an included calcareous disk or knob. However, many wholly calcareous opercula of extinct serpulids have been found, and in some examples have been preserved in the aperture of the tube to which they belong. Unlike the spirally wound opercula of the Vermetidae, the opercula of the Serpulidae are funnel-shaped, and are marked, within the cuplike crown, by numerous fine radii extending outward to the rim of the crown from the somewhat eccentrically located center.

6. Mode of Attachment

The vermetids are cemented to the substrate primarily by their nuclear whorls whereas among the Serpulidae there are many species attached to the substrate for their entire length. The attached side of such serpulids is flattened, and often the margins extend out as a thin plastered rim on the object to which it is affixed.

7. The Anterior Aperture

The anterior aperture or mouth of certain serpulid tubes is often flared outward and is sometimes thickened, whereas the anterior end of most vermetids is simple and of about the same diameter as the tube itself. Successive growth stages of serpulid tubes with a flared and thickened aperture produce funnel-shaped and rather widely spaced concentric ridges as in the genus *Vermiliopsis.*

THE SERPULID TUBE

The particular characters by which the serpulid tube may be recognized are summarized as follows. The serpulid begins as an open-ended apical tube attached to the substrate. The mature tube is calcareous and formed of two distinct layers, the inner compact, porcelaneous and aragonitic, the outer laminated and coated by calcite. The outer layers envelop the bore eccentrically, and in longitudinal section the surface laminae are seen to traverse the wall obliquely or parabolically, with the crest of the parabolas pointing toward the anterior end. The bore of the tube is dull and always smooth. Certain species produce a calcareous operculum, and this resembles a funnel with the stem slightly out of center with the crown. The crown of the operculum is sculptured by numerous radii extending outward from the center. Where the mature tube adheres to a solid object, cellular structures may be formed, though these do not penetrate the inner wall. The margins of the adherent surface of the tube are often extended as a thin ledge, and the adherent surface of the tube is flattened from the attachment.

SYSTEMATIC DESCRIPTIONS

ANNELIDA

POLYCHAETIA

SERPULIDAE

"Serpula" catiana, new species Pl. 19, figs. 1,2; Pl. 20, figs. 1,2

1962. *Serpulorbis* aff. *conicus* (Dillwyn), Weisbord, Bull. Amer. Paleont., vol. 42, No. 193, pp. 160-161, pl. 14, figs. 5-6.

My original description of this form, which I think now may be a serpulid polychaete rather than a vermetid gastropod, was as follows:

> Shell tubular, erratically looped and coiled, subcircular to suboval in cross section, the inferior side flattened from attachment. Interior of tube smooth, the exterior marked with closely spaced scabrous concentric lamellae or with numerous to relatively few low annulations and rugae, some specimens also with broad low longitudinal swellings or ridges.

It should be noted, in addition, that the tube is fairly thick, and that it is built up of annular layers which appear slightly eccentric in cross section. On one specimen (U80a) which is fortuitously spilt lengthwise to reveal the longitudinal structure of the wall, there is the suggestion that the lamellae of the surface continue obliquely on the wall as faint lineations to form what seem to be a series of chevrons or parabolas with the apices pointing forward. This oblique or parabolid course of the growth laminae on the longitudinal section of the wall is characteristic of serpulid polychaetes. In contrast, the lineations on the outer and inner walls of tubicolous gastropods in longitudinal section are disposed normal to the long axis of the tube.

Dimensions.—Holotype (O80a), length of cord between ends of tube 4.8 mm.; max. diameter 1.5 mm. (Fragment of a whorl). Paratype (U80a), length 7.5 mm.; max. diameter 3 mm. (Fragment).

Type locality.—Playa Grande formation (Catia member), on dip slope at W-22, about 100 meters west of Costa fault. Four fragments.

Other localities.—Playa Grande formation (Catia member), south side of Playa Grande road 40 meters southeast of its intersection with the Playa Grande Yachting Club road. Four fragments. Playa Grande formation (Catia member), in stream flowing along the strike of the north flank of the Litoral anticline. One specimen, the identification of which is doubtful. Playa Grande formation (Catia member), south side of coast road at east end of village of Catia La Mar. Nineteen fragments.

Remarks.—As stated in my 1962 paper on Venezuelan gastropods, the fossil tube under discussion so closely resembles a Recent specimen (No. 87976) from Cuba, in the Academy of Natural Sciences of Philadelphia, labeled *Vermetus conicus* (Dillwyn) that I indicated the affinity of the Venezuelan shell to that species under the name of *Serpulorbis* aff. *conicus* (Dillwyn). However, the illustrations in pre-binomial works[2] referred to by Dillwyn (1817, A Descriptive Catalogue of Recent Shells, vol. 2, p. 1078) as exemplifying his *Serpula conica* do not sufficiently resemble my fragments to warrant the implication of such relationship. On the other hand, the description of [*Vermetus conicus*] var. a. *personata* juv. (*Thylacodus*) Mörch by Mörch (1861, pp. 341-342) does suggest a likeness between the St. Croixan Recent tube and the Venezuelan fossil tube, though in the absence of an illustration of *V. conicus personata* and the uncertainty of its classification (vermetid or serpulid), it is thought advisable to apply the new name to the Venezuelan fossil which is now placed in the phylum Annelida, class Polychaetia, and family Serpulidae. There is an interesting parallelism in the occurrence of *V. conicus personata* and *Serpula catiana*: the Recent *V. conicus personata* Mörch from St. Croix was found "on *Isognomon alatum* Gm. from the roots of the *Rhizophora mangle* L. (Oersted)", and in the Catia member of the Playa Grande formation (Pliocene) in which *Serpula catiana*, n. sp. was collected there are cylindrical casts also resembling the stems of mangrove (Weisbord, 1957, p. 13).

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[2] La Trompe d'Éléphant. *Favanne,* i, p. 664, t. 5, f. C.
Rumphius, t. 41, f. 4. *Martini,* i, p. 52, t. 2, f. 15.

"Serpula" incompta (Weisbord) Pl. 19, figs. 3-6; Pl. 20, figs. 3-5

1962. *Serpulorbis incomptus* Weisbord, Bull. Amer. Paleont., vol. 42, No. 193, p. 160, pl. 14, figs. 1-4.

Tube calcareous, sturdy, loosely looped or coiled, but also with hairpin bends, and sometimes slightly twisted. Inferior side flattened or concave from attachment, the superior or free side cylindrical. In cross section the tube is subcircular, with a moderately thick wall and a smooth annulus. The exterior is sculptured by sharp closely spaced concentric lamellae, the lamellae somewhat flexuous in their course around the tube. There are also occasional concentric growth ridges and, on a number of specimens, there are three faint widely spaced longitudinal carinae, one on the middle and one on each side of the superior surface. Most of the specimens have a greater or lesser number of sand grains embedded within the calcareous shell, and these extraneous particles seem to have been agglutinated or incorporated in the shell proper during growth. The grains are more abundant on the attached side of the tube than on the free side, and indicate the character of the substrate on which the form developed. In my original description of this species I used the term "agglutination" for the process of the incorporating of the grains, but this is not to be construed as agglutination in the "purposive" sense as applied, for example, to the true agglutinating annelids in such families as the Pectinariidae and Terebellidae.

Dimensions.—Holotype (I79a), diameter of tube 0.7 mm.; length between ends of loop 2.9 mm. Paratype (I79b), diameter of tube 0.95 mm.; length between ends of loop 2.3 mm. Paratype (I79c), length 7.5 mm.; diameter 2.7 mm.; thickness of wall 0.4 mm. This is a fragment of a large adult tube. Paratype (I79d), length 3 mm.; diameter 0.6 mm. (Fragment).

Type locality.—Lower Mare formation at W-13, on hillside above west bank of Quebrada Mare Abajo. Seven specimens.

Other localities.—Lower Mare formation, in small stream 100 meters west of Quebrada Mare Abajo. Two specimens. Mare formation at W-14, on hillside above west bank of Quebrada Mare Abajo. Two specimens. Mare formation at W-25, south flank of Punta Gorda anticline. Three specimens, one of them referred to this species with doubt. Playa Grande formation (Maiquetía member) at W-23, north flank of Punta Gorda anticline. One specimen.

Remarks.—This species was originally referred by me to the gastropod genus *Serpulorbis*, but further study of the fragments indicates the likelihood that it is a polychaetous annelid in the family Serpulidae. Dr. Meredith Jones of the American Museum of Natural History examined the type and concurs with my revised diagnosis.

The most striking feature of this otherwise nondescript tube is the "agglutination" of sand grains (derived from metamorphic rock) and other extraneous material in the outer wall. Agglutination is a normal process in the building of noncalcareous tubes in the polychaete families Pectinariidae and Terebellidae, but the phenomenon is not often mentioned as occurring in the calcareous tubes of the family Serpulidae. Serpulid species that are cited as having an agglutinated calcareous tube are the Recent *Sabella euplaeana* Delle Chiaje (1828, vol. 3, p. 226) from the Mediterranean, the Recent *Serpula furcifera* Grube (1878, pp. 268-269, pl. 15, fig. 4) from the Philippines, and the fossil *Serpula sabellaria* DeFrance (1827, vol. 48, p. 566) from the Tertiary of Europe. This form of agglutination ("incorporation" might be a better word) in the Serpulidae is not confined to a single genus but is known to occur in a number of genera. For example, *Sabella euplaeana* belongs to the genus *Eupomatus* (*fide* Hartman, 1959, p. 574), and *Serpula furcifera* belongs to the genus *Schizocraspedon* Bush (1904, pp. 179,225,287), a classification based not on the shell characters but on the two deep funnels, one above the other, of the operculum. An agglutinated *Serpula* is represented by *S. sabellaria* DeFrance, but Rovereto (1904b, p. 64) must have been doubtful of the name *Serpula* as he referred to it with a question mark. *Protula* has also been mentioned by Rovereto (1898, p. 51) as a genus which has some agglutinated species, and there are a few sand grains embedded in the coils and base of *Spirorbis* (*Laeospira*) *venezuelensis* Weisbord, n. sp. described in the present work.

The Venezuelan fossil tube under discussion is unlike any of the "agglutinated" forms mentioned above except perhaps *Schizocraspedon furcifera* which was described by Grube as "a cylindrical tube with rugose annulations and three closely spaced low longitudinal carinae on the superior side, covered with grains of sand and minute pebbles agglutinated to it." [Translation]. However, *Schizocraspedon* was classified by Bush not on the tube but on the remarkable development of the operculum. No such diagnostic appurtenances as opercula were found associated with the Venezuelan tube, and as the other "agglutinated" serpulids mentioned above are either geographically remote and living, or if fossil are seemingly unrelated specifically, the generic name *"Serpula"* is applied on the basis of its general resemblance to species of this genus.

Hydroides aff. **bispinosa** Bush Pl. 21, figs. 1-3

1910. *Hydroides bispinosa* Bush, Acad. Nat. Sci. Philadelphia, Proc., vol. 62, p. 496.

1944. *Hydroides bispinosa* Bush, Hartman, Allan Hancock Atlantic Exped., Univ. Southern California Press, Rept. No. 3, p. 26.

1959. *Hydroides bispinosa* Bush, Hartman, Allan Hancock Found. Sci. Res., Occas. Paper, No. 23, p. 578.

1962. *Serpulorbis birugosus* Weisbord, Bull. Amer. Paleont., vol. 42, No. 193, pp. 157-158, pl. 14, figs. 8-9.

This tube from Venezuela was described by me in 1962 under the name of *Serpulorbis birugosus,* n. sp. as follows:

> Shell a long, narrow, gradually enlarging tube randomly looped and coiled, but not twisted, the annulus subcircular, the walls smooth within, the under side of the tube flattened by attachment to other objects, the lateral and upper surface modified a little if in contact with other loops. The margins of the flat inferior side are sharply edged or carinate, the edges themselves adherent and often extending out a short distance as a flat rim on the attached surface. Superior side with two coarse, unequal longitudinal rugae or ridges so situated that one of them is a little nearer the side of the tube than the other. Between, and crossing the longitudinal rugae on the superior surface there are numerous transverse threads, these imparting to the rugae a ropy structure at the crest. The early stage of the tube is whitish, the later stage darker in shade.

To the above description may be added that the tube is calcareous, and that in cross section it is rudely quadrangular by virtue of the two ridges on the dorsal surface and the projecting edge on each side of the base.

Dimensions.—Specimen A82a, diameter of larger end of tube 0.75 mm.; length of specimen (without straightening out the loops) 6.5 mm.; estimated length of straightened tube 25 mm.

Locality.—Recent, on beach of Playa Grande Yachting Club, Distrito Federal. The tube is attached to the interior of the gastropod *Crucibulum auricula* (Gmelin), and when collected in 1956 the tube was empty.

Remarks.—This species occurs together with *Pomatoceros minutus* Rioja, the tubes of each occasionally lying side by side, and sometimes intertwined. Like *P. minutus* Rioja, the present form is found adherent on different species of Mollusca.

The construction of the tube, the smooth wall of the annulus, the flattened underside of the tube (due to attachment), and the manner of looping strongly suggest that the form under consideration is a serpulid polychaete rather than a vermetid gastropod as I originally supposed. However, the specific identity and the generic position is still in doubt, as the animal inhabiting the tube has not been seen.

Comparisons.—There are relatively few species with but two prominent dorsal carinae on the tube, and of those still fewer have been illustrated. Among the unfigured, longitudinally bicarinate tubes is the Recent *Hydroides bispinosa* Bush from Bermuda, and attention is directed to the possibility that the Recent Venezuelan tube here discussed may be the same species. Bush described both the soft parts of the animal and the tube of *Hydroides bispinosa,* the latter as follows: "Tubes much roughened by irregular growth lines crossing two large dorsal carinae, the shallow central area extending forward at the aperture in a broadly rounded projection; attached in irregular flat coils in masses or groups, often much eroded." The Venezuelan tube was empty when collected, and as the correct identification depends in large part on the soft parts of the animal, a study of the whole Venezuelan serpulid will be necessary for confirmation, especially so as Hartman (1959, p. 578) in her "Catalogue of the Polychaetous Annelids of the World" stated that *H. bispinosa* may perhaps be *H. crucigera* Mörch (1863, p. 378), the type of which was collected near Puntarenas, Chile.

Of the longitudinally bicarinate tubes that have been illustrated, I have seen no figures with which the Venezuelan tube corresponds exactly, though there is some resemblance to *Pomatoceros caeruleus* (Schmarda) (1861, pp. 29-30, pl. 21, fig. 178; as *Placostegus*). Both *P. caeruleus* and the Venezuelan tube are characterized by two longitudinal ridges on the dorsal surface, but the ridges on *P. caeruleus* as shown on Schmarda's original figure are much sharper than on the Venezuelan tube, and are traversed by fine widely spaced transverse growth lines rather than by coarse crowded transverse wrinkles as on the Venezuelan specimen. Furthermore the tube of *P. caeruleus* is bluish whereas the Venezuelan one is white posteriorly, becoming a nondescript tan anteriorly.

Another unfigured species which the Venezuelan tube seems to resemble from the descriptions, is *Eupomatus sanctae crucis* (Krøyer) Mörch (1862, pp. 378-379, No. 9) which has been reported from St. Croix, Haiti, México, and French Guiana. Tubes of *E. sanctae crucis* from French Guiana have been described thusly by Fauvel (1919a, pp. 478-479): "Numerous specimens with their tube. The tube calcareous, whitish, irregularly looped, attached lightly to the support to which it adheres. It is wrinkled transversely and ornamented by two very obtuse longitudinal ridges, often wanting." [Translation]. It is also stated by Fauvel that though there are minor differences in the soft part of the animal it is possible that *E. sanctae crucis* is simply a variant of *E. uncinatus* Philippi (1844, Ann. Mag. Nat. Hist., ser. 1, vol. 14, p. 160) from the Mediterranean. The Venezuelan tube described herein differs from *E. sanctae crucis* in being firmly attached and in having two prominent dorsal ridges rather than obtuse or wanting ones.

Range and distribution.—If the identity of the Venezuelan tube is authenticated, a second record of its occurrence will have been established. The species was described originally from Bermuda. From its association with littoral molluscan shells, a shallow-water habitat is indicated.

Eupomatus cf. **dianthus** (Verrill) Pl. 22, figs. 1,2

1841. *? Serpula vermicularis* Gould, Rept. Invert. Massachusetts, p. 10. Not of Linnaeus.
1873. *Serpula dianthus* Verrill, U. S. Com. Fish and Fisheries, Rept. of Commissioner, pp. 322,620.
1873. *Serpula dianthus* var. *citrina* Verrill, U. S. Com. Fish and Fisheries, Rept. of Commissioner, pp. 322, 620-621.
1878. *Hydroides dianthus* (Verrill), Coues and Yarrow, Acad. Nat. Sci. Philadelphia, Proc., vol. 30, p. 300.
1879. *Hydroides dianthus* (Verrill), Preliminary check-list of the marine Invertebrata of the Atlantic Coast, from Cape Cod to the Gulf of St. Lawrence, p. 11.
1879. *Hydroides dianthus* (Verrill), Webster, Albany Inst., Trans., vol. 9, p. 266.
1880. *Hydroides dianthus* (Verrill), Webster, New York State Mus., Thirty-second An. Rept., p. 128.
1881. *? Hydroides dianthus* (Verrill), Connecticut Acad. Arts and Sci., Trans., vol. 4, No. 8, pt. 1, pp. 288,303,319,322.
1884. *Hydroides dianthus* (Verrill), Webster, U. S. Nat. Mus. Bull. 25, pt. 7, p. 327.
1884. *Hydroides dianthus* (Verrill), Webster and Benedict, U. S. Fish Com., vol. for 1881, p. 737.

1887. *Hydroides dianthus* (Verrill), Benedict, U. S. Nat. Mus., Proc., vol. 9, p. 549, pl. 20, fig. 10.
1891. *Hydroides dianthus* (Verrill), Andrews, U. S. Nat. Mus., Proc., vol. 14, p. 299.
1891. *Hydroides dianthus* (Verrill), Andrews, Jour. Morph., vol. 5, p. 285.
1891. *Serpula dianthus* Verrill, Treadwell, Zool. Anzeig., vol. 14, pp. 276-280, 2 figs.
1900. *Hydroides dianthus* (Verrill), Wilson, Amer. Naturalist New York, vol. 34, p. 351.
1905. *Hydroides dianthus* (Verrill), Zeleny, Biol. Bull. Woods Hole, vol. 8, p. 311, 3 figs.
1906. *Hydroides dianthus* (Verrill), Hargitt, Jour. Exper. Zool., vol. 3, pp. 295-320, figs. 1-2.
1909. *Hydroides dianthus* (Verrill), Hargitt, Jour. Exper. Zool., vol. 7, pp. 157-187, 7 tables.
1910. *Hydroides dianthus* (Verrill), Hargitt, Amer. Naturalist New York, vol. 44, pp. 376-378.
1913. *Hydroides dianthus* (Verrill), Sumner, Osburn, and Cole, U. S. Bur. Fish., Bull., vol. 31, p. 631.
1933. *Hydroides dianthus* (Verrill), Grave, Biol. Bull. Woods Hole, vol. 65, pp. 380-382.
1936. *Hydroides hexagona* Bosc, Pearse, Elisha Mitchell Sci. Soc., Jour., vol. 52, p. 181.
1942. *Hydroides hexagona* Bosc, Pearse, Pearse, Humm, and Wharton, Ecol. Monogr., vol. 12, p. 183.
1943. *Hydroides hexagona* Bosc, Pearse, McDougall, Ecol, Monogr., vol. 13, p. 341.
1944. *Hydroides dianthus* (Verrill), Hartman, Amer. Mus. Nat. Hist., Bull., vol. 82, art. 7, pp. 335,343.
1945. *Eupomatus dianthus* (Verrill), Hartman, Duke Univ. Marine Sta., Bull., vol. 2, p. 48.
1950. *Eupomatus dianthus* (Verrill), Hedgpeth, Inst. Marine Sci. Univ. Texas, Publ., vol. 1, No. 2, p. 75.
1950. *Eupomatus dianthus* (Verrill), Behre, Marine Lab. Louisiana State Univ., Occas. Papers, No. 6, p. 14.
1951. *Eupomatus dianthus* (Verrill), Hartman, Inst. Mar. Sci. Univ. Texas, Publ., vol. 2, No. 1, pp. 118-119.
1956. *Eupomatus dianthus* (Verrill), Menzel, Oceanogr. Inst. Florida State Univ., Contrib. No. 61, p. 15.
1956. *Eupomatus dianthus* (Verrill), Hartman, Amer. Mus. Nat. Hist., Bull., vol. 109, art. 2, p. 250.
1957. *Eupomatus dianthus* (Verrill), Rioja, Inst. Biol. México, An., vol. 28, pp. 260-262 fig. 5.
1959. *Eupomatus dianthus* (Verrill), Hartman, Allan Hancock Found. Sci. Res., Occas. Paper, No. 23, p. 574.
1962. *Eupomatus dianthus* (Verrill), Jones, Amer. Mus. Nat. Hist., Bull., vol. 124, art. 5, p. 207.

The Recent serpulid specimens here compared with *Eupomatus dianthus* (Verrill) are represented by one juvenile and several adult tubes, all of them incomplete and without the soft parts of the animal. The tube is calcareous, slender, moderately sturdy, cylindrical, gradually enlarging, and firmly attached throughout its length. Its course is sinuous and randomly looped. In cross section the tube is subcircular, and the annulus is smooth.

The apical tip of the juvenile specimen is missing, but from the posterior end for a length of about two millimeters the tube is whitish, subhyaline, and of nearly constant diameter. There is then an abrupt but slight enlargement of the tube, and thereafter the tube is dense and the enlargement with growth very gradual. Except for the posterior end, the juvenile tube is whitish with irregular concentric bands of light tan. The free side of the juvenile tube is marked on the exterior by fairly numerous low concentric wrinkles or rugae which are rather irregular except on the subhyaline posterior end where they are faint and more or less regular in spacing. The adult tubes are worn but they too are girdled by concentric wrinkles, and are ornamented additionally by two or three very faint longitudinal carinae. The anterior end of the tubes is slightly expanded but the true aperture has not been observed.

Dimensions.—Specimen A671a (incomplete juvenile), approximate length (straightened out) 10 mm.; diameter at anterior end 0.5 mm.; approximate diameter near posterior end 0.2 mm. Specimen A671b (incomplete adult), approximate length (straightened out) 25 mm.; diameter at anterior end 0.8 mm.

Locality.—Recent, on beach at Playa Grande Yachting Club, Distrito Federal. The juvenile tube is attached to the dead gastropod shell *Cantharus auritulus* (Link), and the adult tubes attached to the dead pelecypod shell *Arca imbricata* Bruguière. On the latter, *Eupomatus* cf. *dianthus* is intertwined with *Pomatoceros minutus* Rioja.

Remarks.—Without the soft parts or operculum, the identity of the tubes in question must remain inconclusive, though they cannot be distinguished superficially from specimens of *E. dianthus* dredged near Biloxi, Mississippi, in the Gulf of Mexico. As pointed out to me by Olga Hartman, however, the tube is also similar to that of *E. lunulifer* Claparède (1870, pp. 181-182, pl. 31, fig. 3) originally described from the Bay of Naples but reported by Hartman (1944b, pp. 6,25) from three miles north of Coche Island, Venezuela, in 21-33 fathoms. Dr. Hartman was good enough to give me a cluster of empty adult tubes from the station near Coche Island and from the station near Biloxi, Mississippi, and there is indeed a general resemblance of the tubes from Biloxi, Coche, and Playa Grande. I have seen no illustrations of the tube of *E. lunulifer,* and I do not know if the type possesses the longitudinal carinae for they were not mentioned by Claparède in his original description of the tube which was as follows:

> Tubuli cretacei, cylindracei, agglomerati, flexuosi.
> J'ai reçu cet *Eupomatus* une seule fois, mais en nombre très considerable. Il avait été trouvé fixé à la coque d'un bâtiment en radoub.

On the other hand it is known that faint longitudinal carinae do occur on the adult tube of *E. dianthus* as was noted by Verrill (1873, p. 670), who described the tubes as "long, variously crooked, and often contorted, sometimes solitary, frequently aggregated into masses four or five inches in diameter. They are nearly cylindrical, with irregular lines of growth and sometimes with faint carinations."

References to *E. lunulifer* Claparède that have come to my notice are listed below.

1870. *Eupomatus lunulifer* Claparède, Soc. Phys. Hist. Nat Genève, Mém., vol. 20, pp. 181-182,441, pl. 31, fig. 3.
1893. *Hydroides lunulifer* (Claparède), Lo Bianco, R. Accad. Sci. Fis. Nat. Napoli, Atti, ser. 2, vol. 5, No. 11, p. 85.
1898. *Hydroides lunulifer* (Claparède), Rovereto, Palaeont. Italica, vol. 4, p. 66.
1906. *Hydroides lunulifer* (Claparède), Saint-Joseph, Ann. Sci. Paris, sér. 9, vol. 3, p. 247.
1910. *Eucarphus serratus* Bush and *Eucarphus lunulifer* (Claparède) Bush, Acad. Nat. Sci. Philadelphia, Proc., vol. 62, p. 495.
1921. *Eupomatus lunulifer* Claparède, Iroso, Staz. Zool. Napoli, Pubbl., vol. 3, p. 52.
1923. *Hydroides lunulifer* (Claparède), Rioja, Mus. Nac. Cienc. Nat., Trab., ser. Zool., vol. 48, p. 86, fig. 144.
1927. *Hydroides lunulifer* (Claparède), Fauvel, Faune de France, vol. 16, pp. 358-359, fig. 122, p-s.
1933. *Hydroides lunulifer* (Claparède), Monro, Zool. Soc. London, Proc., pt. 2, pp. 1040,1082.
1944. *Eupomatus lunulifer* Claparède, Hartman, Allan Hancock Atlantic Expedition, Univ. Southern California Press, Rept. No. 3, pp. 6,25.
1959. *Eupomatus lunulifer* Claparède, Hartman, Allan Hancock Found. Sci. Res., Occas. Paper, No. 23, p. 574.
1962. *Eupomatus lunulifer* Claparède, Jones, Amer. Mus. Nat. Hist., Bull., vol. 124, art. 5, p. 207.

Although *E. dianthus* is "native" to the east coast of the United States and *E. lunulifer* "native" to the Mediterranean, the occurrence of these species in other waters may be explained by their attachment to the hull of vessels and their conveyance by them.

Range and distribution.—*Eupomatus dianthus* has been reported from the Western Atlantic, the Gulf of Mexico, and the West Indies, *E. lunulifer* from the Mediterranean, the Caribbean, and the Indian Ocean.

Pomatoceros minutus Rioja Pl. 21, figs. 4,5; Pl. 22, figs. 3,4

1941. *Pomatoceros minutus* Rioja, Inst. Biol. México, An., vol. 12, pp. 734-738, pl. 9, figs. 15-26.

1942. *Pomatoceros minutus* Rioja, Inst. Biol. México, An., vol. 13, pp. 130-132, figs. 15-20
1946. *Pomatoceros minutus* Rioja, Inst. Biol. México, An., vol. 17, pp. 201-202.
1951. *Pomatoceros minutus* Rioja, Hartman, Inst. Marine Sci. Univ. Texas, Publ., vol. 2, No. 1, pp. 119-120.
1958. *Pomatoceros minutus* Rioja, Inst. Biol. México, An., vol. 29, p. 296.
1958. *Pomatoceros caerulescens* Augener, Rioja, Inst. Biol. México, An., vol. 29, p. 296. Not of Augener.
1958. *Pomatoceros caeruleus* Schmarda, Rioja, Inst. Biol. México, An., vol. 29, p. 296. Not of Schmarda.
1959. *Pomatoceros minutus* Rioja, Hartman, Allan Hancock Found. Sci. Res., Occas. Paper, No. 23, pt. 2, p. 587.
1962. *Serpulorbis catella* Weisbord, Bull. Amer. Paleont., vol. 42, No. 143, pp. 156-157, pl. 13, figs. 17-18.

The Venezuelan tubes here referred to *Pomatoceros minutus* Rioja are small, whitish, and calcareous, with the inferior side firmly adherent throughout its length. Initially, the tube is slenderly cornucopia-like, with a curved to nearly coiled apex, but with growth the diameter enlarges gradually and slowly. In its course, the tube is sinuous, sprawling, sometimes a little twisted, and generally loosely and randomly looped. An occasional tube is tightly coiled, with the coils appressed one on the other. The attached, or inferior side is flat to slightly concave, and the margins extend out as a thin plastered rim on the object to which the shell is affixed. On the dorsal, or free surface there are three primary longitudinal ridges, of which the middle ridge, situated more or less along the crest, is somewhat more prominent and slightly larger than the ones on either side, the latter either fairly close to, or somewhat distant from the middle one. The ridges are generally sharp in the early stage or posterior end of the tube but become coarser toward the apertural end, and are crossed by numerous fine transverse growth rugae. On specimens from the type locality (Acapulco, México), the medial ridge forms a toothlike hook on top of the aperture, and this is present on one of the Recent Venezuelan tubes. Between the longitudinal ribs, as well as on the sides of the tube, are a regular series of short horizontal rather closely spaced slots or pits so arranged as to impart a reticulate and chainlike appearance. These slots terminate at the projecting rim of the base, and are replaced on the rim by transverse threads which form a fringe effect on the margin. A longitudinal section through the tube reveals that the slots lead into alveolae or cells which in turn are separated from the annulus of the tube by a thin wall. In cross section, the tube is substellate, with the three prongs of the dorsal side representing the three ridges which traverse that side, and with the prong on each side of the base representing the basal rim. Larger tubes may have a minor longitudinal ridglet or two on the lateral surface, and it was to such a tube that I gave the name *"Serpulorbis" catella* in the class Gastropoda but which now seems to me to be a variant of *Pomatoceros minutus* Rioja in the class Polychaetia.

Dimensions.—Fossil specimen D77a, length of fragment 2.9 mm.; diameter of larger end 0.6 mm. Recent specimen A77b (attached to the aperture of *Nitidella laevigata* (Linnaeus), approximate length of incomplete specimen if straightened out 4.5 mm.; max. diameter at aperture 0.5 mm. Fossil specimen J77a (attached to the interior of *Chlamys gibbus antecessor* Weisbord), length (straightened out) 10 mm.; diameter at aperture 0.7 mm.

Localities.—Lower Mare formation, in small stream 100 meters west of Quebrada Mare Abajo. Two specimens. Upper Mare formation at W-14, on hillside above west bank of Quebrada Mare Abajo. Six fragments. Abisinia formation at W-30, eastern edge of Playa Grande village. One fragment. Recent, on beach of Playa Grande Yachting Club, Distrito Federal. Fairly common on dead mollusks, attached to (among others) the following species: *Nitidella nitida* (Lamarck), *Nitidella laevigata* (Linnaeus), *Cheilea equestris* (Linnaeus), *Capulus intortus* (Lamarck), *Hipponix antiquatus* (Linnaeus), *Cantharus auritulus* (Link), *Ancilla tankervillei* (Swainson), *Pisania pusio* (Linnaeus), *Conus mus* Hwass, *Thais rustica* (Lamarck), *Arca zebra* Swainson, and *Arca imbricata* Bruguière. Recent, on beach southeast of Higuerote, State of Miranda, attached to *Solen obliquus* Spengler.

Remarks.—The Recent and fossil tubes from northern Venezuela are so similar to the excellent descriptions and illustrations of *P. minutus* Rioja given in 1941, 1942, and 1946, that they must be considered one and the same. In 1958, however, Rioja synonymized his *P. minutus* with *P. caerulescens* Augener (1922), and the latter, in turn, with *P. caeruleus* (Schmarda) which was first recorded from South Africa and New Zealand. Rioja's comments (1958, p. 296), translated from the Spanish, are as follows:

> We believe that the species described by Augener (1922) and by us (Rioja, 1941) can be assimilated with the species of Schmarda, as well as with others described in tropical seas. Perhaps *Pomatoceros paumotanus* Chamberlin may be assimilated with it, given the variability that the operculum presents in the species of this genus.
>
> Locality: Augener cites this species from Campeche Bank. In 1946 we cited this species from Veracruz, where many examples were collected on algae. On the excursion taken in 1957 we were able to verify its occur-

rence on shells, algae and madrepores on the islands of Sacrificios, Verde and Santiaguillo.

Comparing Rioja's *P. minutus* tube with that of *Placostegus caeruleus* Schmarda (1861, pp. 29-30, pl. 21, fig. 178), it is seen that they differ markedly, with *P. caeruleus* lacking the intercostal slots so characteristic of *P. minutus,* and in the blue-tinted shell compared with the white one of *P. minutus.* This can hardly be ascribed to the variability of tubes of the same species, as all individual specimens of *P. minutus* exhibit the slotted structure which is a surprisingly constant one. Also, *P. caeruleus* has but two longitudinal ribs on the dorsal surface, and they are sharp, nearly equal, and widely separated. *P. minutus,* on the other hand, has three longitudinal ribs on the dorsal surface, and these are closer together, with the medial one slightly stronger than the others. For these reasons I am persuaded that *P. minutus* is not the same as *P. caeruleus* (Schmarda).

Inasmuch as Augener neither described nor illustrated the tube of his *P. caerulescens* it cannot be clearly demonstrated that Rioja's *P. minutus,* which has a unique alveolar construction, is the same species. According to Augener, *P. caerulescens* "is very similar to the *Pomatoceros caeruleus* Schm., but without buccal setae." [Translation]. If this similarity includes the tube, then *P. caerulescens* Augener also differs markedly from *P. minutus* Rioja, as the tube of *P. minutus* is unlike that of Schmarda's *P. caeruleus.* Therefore, I would consider *P. minutus* Rioja a valid species. This view is also held by Hartmann (1951b, 1959) who listed *P. caeruleus* (Schmarda), *P. caerulescens* Augener, and *P. minutus* Rioja as separate species.

Range and distribution.—Lower Pliocene to Recent. *Pomatoceros minutus* Rioja was first described living at Acapulco, México, where it is common, and occurs singly or in clusters on algae. It was later reported from Mazatlan and from the mouth of Río Mayo, Golfo de California, at a depth of about 8 fathoms. It is now known to be living on the Atlantic side of México in the Veracruz region where it is attached to shells, algae, and corals. The present notice of its occurrence in Venezuela is the first, having been found both as a fossil (in the lower Pliocene Mare formation and in the Pleistocene Abisinia formation), and in the Recent in shallow marine waters. All of the Recent tubes collected by the writer were empty.

Protula ? playagrandensis, new name Pl. 21, figs. 6,7

1962. *Serpulorbis pallidus* Weisbord, Bull. Amer. Paleont., vol. 42, No. 193, p. 162, pl. 14, fig. 7.

The original description of this species under the name of *Serpulorbis pallidus* was as follows:

> Shell a coiled, slightly twisted, narrowish tube, rudely subcircular in cross section, the interior smooth, the outer surface a little gnarled or constricted here and there, marked with numerous but exceedingly faint concentric striations and occasional fine concentric growth rifts.

Dimensions.—Holotype (M81a), diameter of tube 0.35 mm.; length of specimen 2.6 mm.

Type locality.—Playa Grande formation (Catia member), south side of Playa Grande road, 40 meters southeast of its intersection with the Playa Grande Yachting Club road. One specimen, the holotype, on which the outer coating of the shell is partially peeled away in places.

Remarks.—The type (26102 PRI) is a slender calcareous tube with a nearly constant diameter. The tube appears to be made up of two layers of shell, the outer a dull white, the inner a light tan. If it is revealed in better material that there are only two layers of shell, that evidence would indicate that the form is indeed a serpulid polychaete rather than a vermetid gastropod as I had first surmised, as vermetids are built up of three layers of shell. Granting that the tube in question is a serpulid (and this was suggested to me by Dr. Benjamin F. Howell of Princeton University and concurred in by Dr. Meredith Jones of the American Museum of Natural History) the new name of *Protula ? playagrandensis* is proposed. The designation *Protula ? pallida* (Weisbord) would be invalid as that is preempted by *Protula pallida* Iroso (1921, p. 66) a dissimilar Recent species from the Bay of Naples.

Comparisons.—Of the species of *Protula* with which the present tube has been compared, *P. ? playagrandensis* exhibits some resemblance to the cold-water *Protula americana* M'Intosh (1885, pp. 512-414, pl. 54, fig. 3), first reported from south of Halifax, Nova Scotia, at a depth of 85 fathoms and bottom temperature of 35°F. However, aside from its larger size, the tube of *P. americana* is subquadrate to subtrigonal in cross section whereas the Venezuelan tube is subcircular. Some authors would place *P. americana* in synonymy with the Recent *Subprotula appendiculata* (Schmarda) (1861, p. 33, pl. 22, fig. 125) from Jamaica, but the illustration of *S. appendiculata* shows that the forward end of the tube enlarges rather rapidly in diameter, whereas the diameter of *P. americana* enlarges so gradually as to seem nearly constant.

Spirobis (Laeospira) venezuelensis, new species
Pl. 19, figs. 7-10; Pl. 20, figs 6,7

Tube small, calcareous, umbilicate, moderately plump, sinistrally and tightly coiled into a subcircular ring. Coils about one and a half in number, the superior coil adherent to and flattened upon the inferior, the innermost turn completely covered. Umbilicus somewhat off center due to the progressive enlargement of the whorls with growth, and the diameter of the ring is a little greater along the axis which parallels the aperture. Aperture large, suboval, thickened, and rolled outward or reflected at the margin. Entire base of ring flattened from attachment, the base irregularly and sharply carinate at the edge. Free side marked by prominent but low, rounded subequal concentric undulations. On a few undulations of the holotype there appear locally extremely faint microscopic decussations which impart a pseudo-reticulate pattern, but the reticulations are not persistent, and the scupture is essentially concentric. Imbedded and widely scattered on the surface of the coils, as well as on the base, are a few minute grains of sand from the substrate on which the organism dwelt.

Dimensions.—Holotype (M76a), maximum diameter 2.2 mm.; minimum diameter 2 mm.; altitude 1.15 mm.; maximum diameter of aperture 0.95 mm. Paratype (E76a), maximum diameter 1.3 mm.; minimum diameter 1.05 mm.; maximum diameter of aperture 0.8 mm.

Type locality.—Playa Grande formation (Catia member) at W-15, south side of Playa Grande road 40 meters southeast of its intersection with the Playa Grande Yachting Club road. One specimen, the holotype.

Other localities.—Upper Mare formation, 115 meters south-southwest of the crossing of Quebrada Mare Abajo and coast road, and 90 meters southeast of W-12. One specimen, the paratype, attached to a barnacle of the genus *Balanus.* Upper Mare formation, in stream 250 meters south-southwest of the mouth of Quebrada Las Pailas. One specimen, attached to a barnacle.

Remarks.—"Sinistral" tubes of *Spirorbis,* or tubes which, with the base down, are coiled clockwise toward the aperture, are classified by Fauvel (1927a, pp. 396-404) into three subgenera: *Paralaeospira* Caullery and Mesnil, *Leodora* Saint-Joseph, and *Laeospira* Caullery and Mesnil. As these taxa are based on the soft parts of the animal (*Paralaeospira* has four thoracic setigerous segments, *Leodora* and *Laeospira* three such segments), the subgeneric classification of the fossil *S. venezuelensis,* n. sp. is a matter of surmise. However, the subgenus *Laeospira* is employed in this work as it seems to accord with Fauvel's description (Fauvel 1927a, p. 399) of the tube which is as follows: "Tube sénestre, calcaire, souvent rugueux et empâté, décrivant 2 à 4 spires nautiloides autor d'un ombilic assez profond."

I have seen no other form to which *S. venezuelensis* is closely related, though there is a resemblance to certain variants of *S. spirorbis* (Linnaeus). *S. spirorbis* (see Schmidt 1955a, p. 81, for synonyms) is a widespread species living in the North Atlantic to the Mediterranean and ranging as far back in time as the middle Miocene. Illustrations of *S. spirorbis* show a carina around the umbilicus which is wanting on *S. venezuelensis,* and the prominent concentric undulations that are present on *S. venezuelensis* are wanting on *S. spirorbis.*

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PLATES

EXPLANATION OF PLATE 19

Figure Page

1, 2. **"Serpula" catiana** Weisbord, n. sp. 152

Holotype (O80a), 26101 PRI. Diameter of tube at larger end 1.5 mm. Fig. 1, superior or free side; fig. 2, inferior or attached side. Playa Grande formation (Catia member).

3-6. **"Serpula" incompta** (Weisbord) 154

Figs. 3,4, holotype (I79a), 26099 PRI. Diameter of tube 0.7 mm. Fig. 3, superior or free side; fig. 2, inferior or attached side. Figs. 5,6, paratype (I79b), 26100 PRI. Diameter of tube 0.95 mm. Fig. 5, superior or free side; fig. 6, inferior or attached side. Lower Mare formation.

7-10. **Spirorbis (Laeospira) venezuelensis** Weisbord, n. sp. 166

Holotype (M76a), 26908 PRI. Maximum diameter 2.2 mm. Figs. 7,8, views of free side; fig. 9, end view showing aperture; fig. 10, base or attached side. Playa Grande formation (Catia member).

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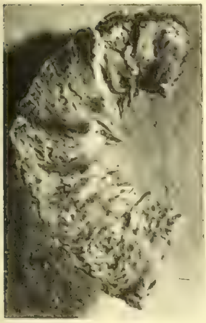

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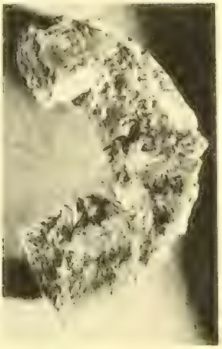

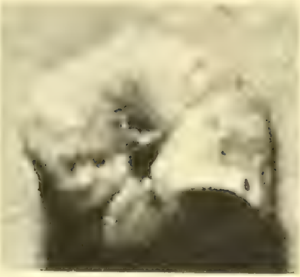

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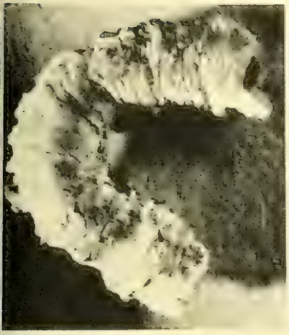

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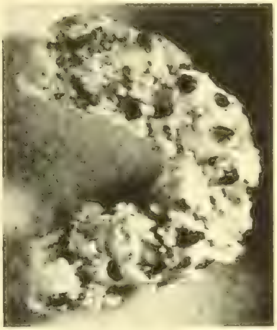

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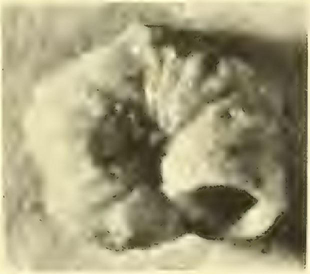

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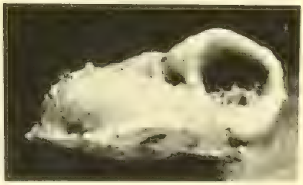

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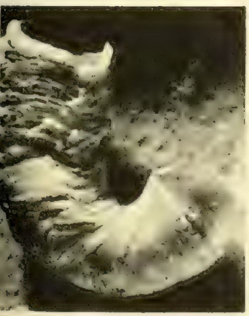

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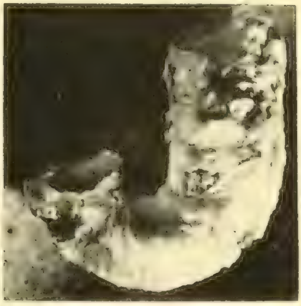

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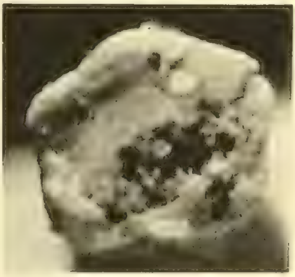

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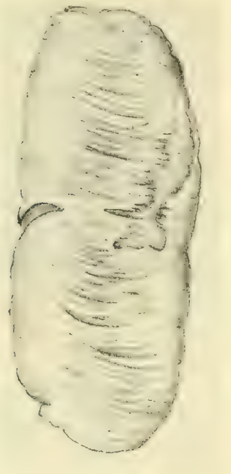
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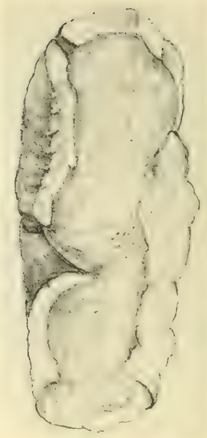
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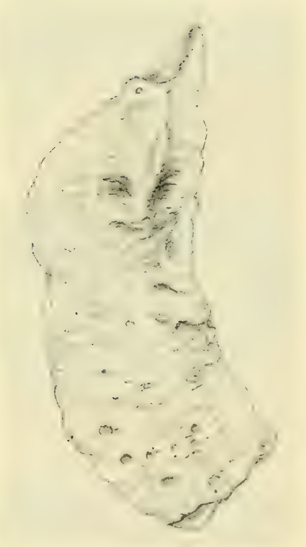
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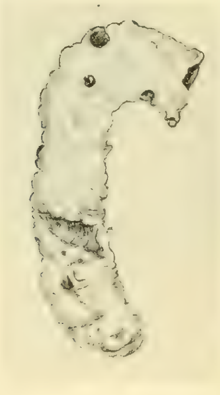
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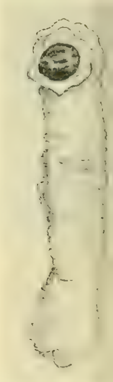
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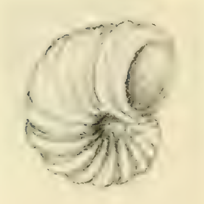
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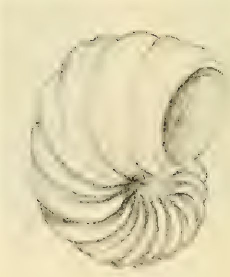
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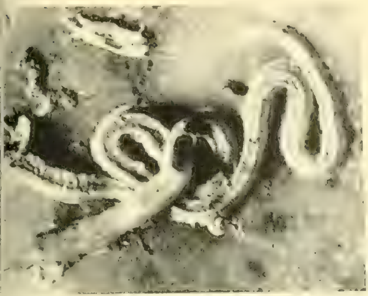

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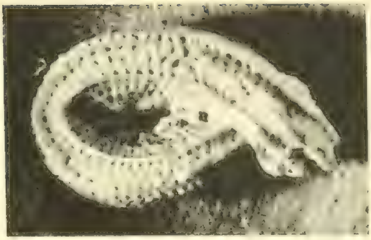

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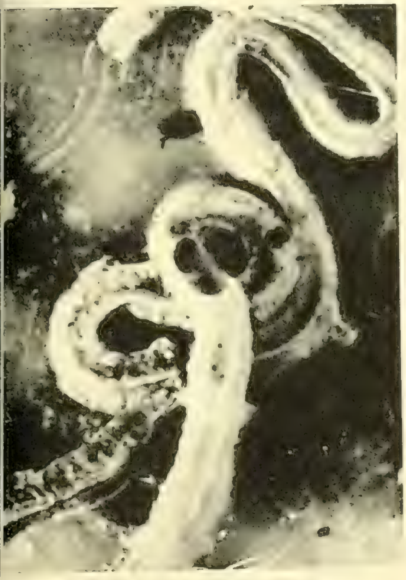

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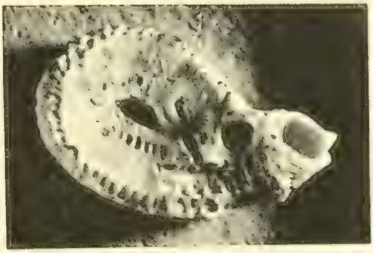

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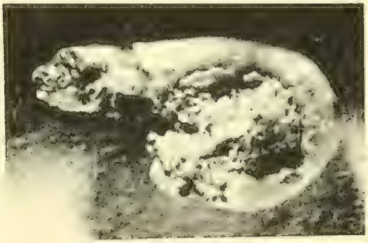

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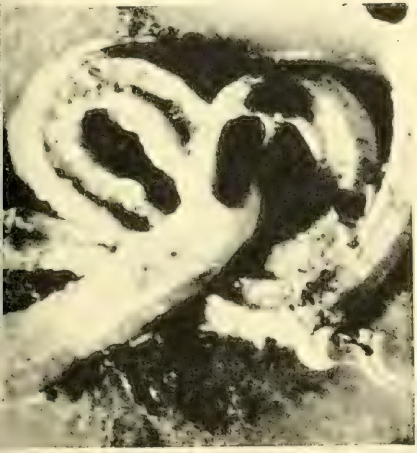

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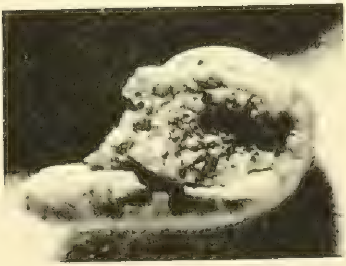

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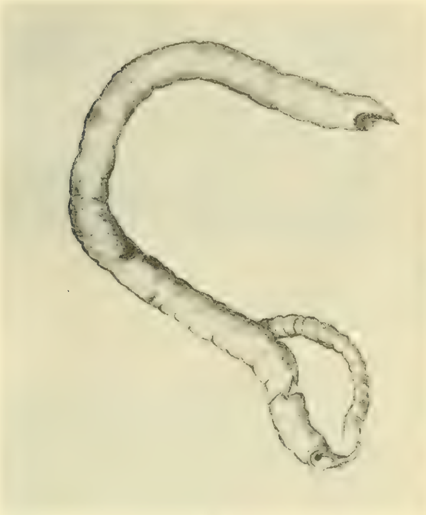

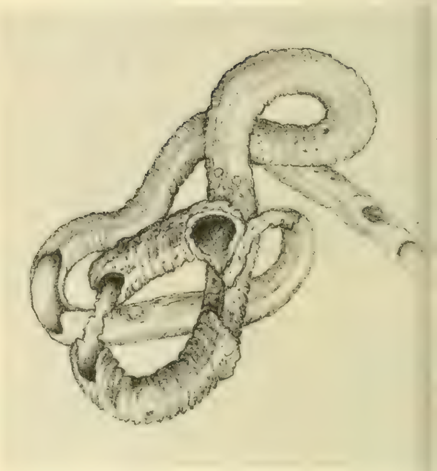

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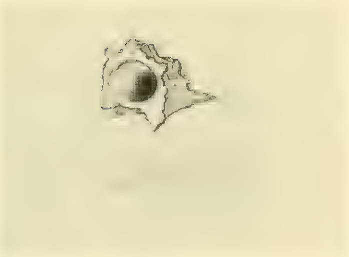

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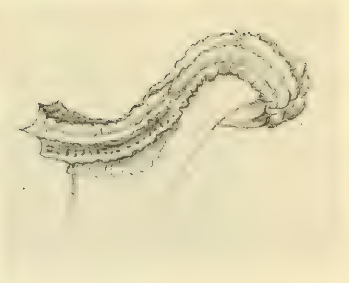

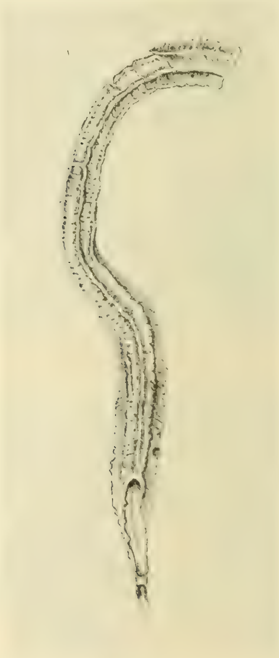

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EOCENE AND MIOCENE FORAMINIFERA FROM TWO LOCALITIES IN DUPLIN COUNTY, NORTH CAROLINA

by

Charles W. Copeland

June 30, 1964

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EOCENE AND MIOCENE FORAMINIFERA FROM TWO LOCALITIES IN DUPLIN COUNTY, NORTH CAROLINA

Charles W. Copeland

ABSTRACT

Eocene and Miocene Foraminifera were studied from two localities in Duplin County, North Carolina, to expand the knowledge of Foraminifera from the Eocene Castle Hayne and Miocene Duplin marl and to gather further information concerning the biostratigraphic relations of both these faunas. Previous regional studies have placed little emphasis on the North Carolina Foraminifera.

Fifty-nine species of Foraminifera were found in the Castle Hayne formation at Natural Well, near Magnolia, North Carolina, and 44 species were found in the Duplin marl at Natural Well and from a locality on the Barwick farm, between Magnolia and Kenansville, North Carolina.

The Castle Hayne foraminiferal fauna is of upper lower to lower middle Jackson age and is typical of faunas found in the inner sublittoral zone at depths from 60-120 feet.

The upper Miocene Duplin assemblage is typical of faunas found in the inner sublittoral zones at depths from 30-60 feet.

INTRODUCTION

PURPOSE OF THE INVESTIGATION

The investigation originally was begun to expand the knowledge of Miocene Foraminifera from the Duplin marl and the stratigraphic relations of the Duplin marl foraminiferal fauna. The localities were chosen for comparative purposes, one at Natural Well and the other about 6.2 miles northeast, at the farm of Mr. and Mrs. R. E. Barwick.

Natural Well has long been famous as a collecting locality for upper Miocene invertebrates, mostly of the phylum Mollusca. Approximately 400 invertebrate species have been reported from the locality (Richards, 1950, p. 29).

A survey of the literature concerning Natural Well revealed that an upper Eocene age was assigned to the beds underlying the Duplin marl by Huddle (1940, p. 228) on the basis of the microfossils. The microfossils were not described nor figured by Huddle and, therefore, the upper Eocene Foraminifera are also included in this paper.

LOCATION AND DESCRIPTION OF AREAS STUDIED

NATURAL WELL LOCALITY

Natural Well is located two miles southwest of Magnolia in Duplin County, North Carolina, on the farm of Mr. Albert Matthews (Fig. 1). The well is about 500 yards southeast of the farmhouse.

Natural Well is a nearly circular sinkhole about 100 feet in diameter and approximately 27 feet deep. The wall on the north and west sides is nearly vertical, but on the south and east sides the wall slopes enough to permit access to the outcropping formations. At the bottom of the sink is a pond about 30 feet in diameter. The water level in the pond fluctuates seasonally. The outcrop is in poor condition at the present time due to the numerous excavations in the sides of the well by visiting fossil collectors.

The section exposed at the well from the waterline to the rim is as follows: 13 feet of the Castle Hayne formation, 3-5 feet of the Duplin marl, and 10 feet of probable Pleistocene sand. Further details of the stratigraphy are discussed later in the paper.

BARWICK FARM LOCALITY

The Barwick farm is located 4.2 miles northeast of Magnolia on the road between Magnolia and Kenansville, North Carolina (Fig. 1). The marl pit where the samples were taken is about 75 yards south of the highway.

The marl pit is rectangular, about 150 feet long and 50 feet wide. The pit was dredged to a shallow depth and the spoil was deposited along the sides. The pit is now filled with water which limits access to the Duplin marl. Approximately five feet of the Duplin marl are exposed above the waterline and are overlain by about three feet of supposed Pleistocene sand.

PREVIOUS INVESTIGATIONS

The Natural Well fauna has been described or reported by a number of investigators including Conrad (1838), Dall (1903, p. 1598), Miller (1912, p. 241), Olsson (1916), Cushman (1918, p. 42), Edwards (1944), Gardner (1943, 1948), and Dawson (1958). Cushman and Edwards were the only two that described microfossils from the locality. Cushman reported two species of Foraminifera and Edwards described the ostracods.

The light green sediments underlying the Duplin marl at Natural Well have received the attention of several investigators

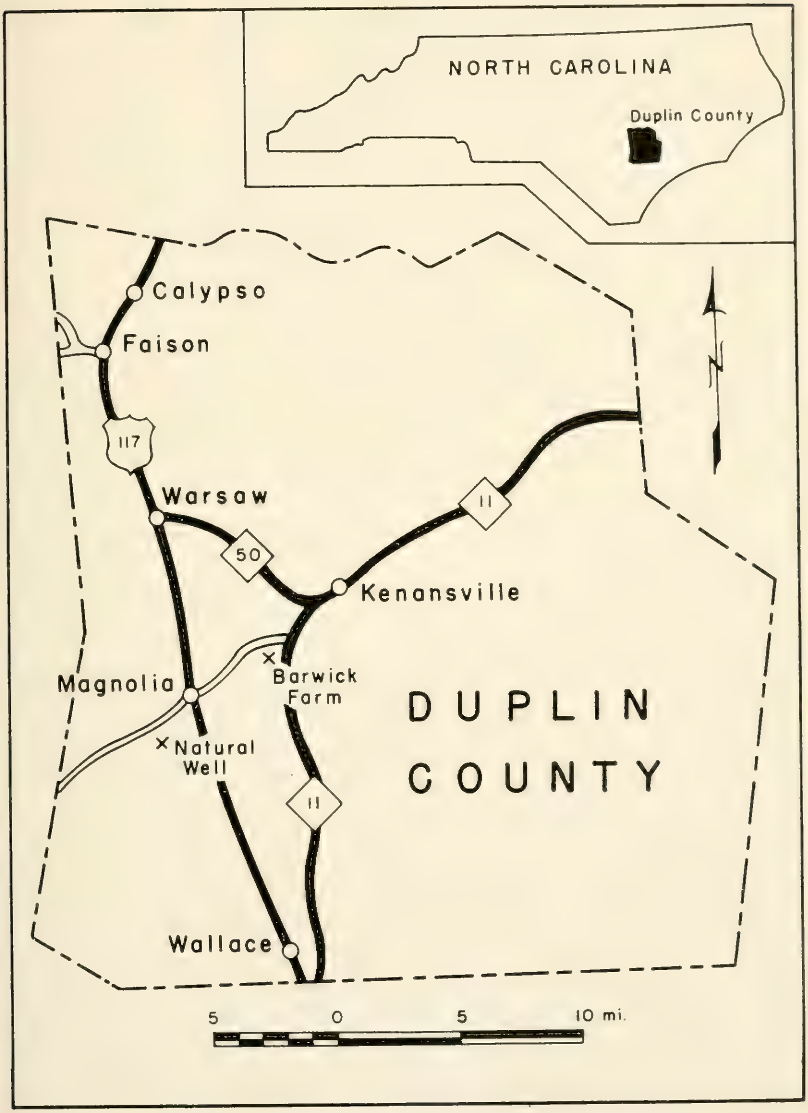
NORTH CAROLINA
Duplin County
Calypso
Faison
117
Warsaw
50
11
Kenansville
Barwick Farm
Magnolia
Natural Well
DUPLIN COUNTY
11
Wallace
N
5
0
5
10 mi.

FIGURE 1. INDEX MAP OF LOCALITIES

beginning with Kerr in 1875 (p. 149), who stated the sediments were of Eocene age on the basis of lithology. Miller (1912, p. 241) included these beds in the upper Miocene Duplin marl. Huddle (1940, p. 228), in a short geological note, said the sediments were probably of upper Eocene age on the basis of the microfossils. In a description of the Natural Well locality, Richards (1950, p. 17) placed the light green sediments underlying the Duplin marl in the Castle Hayne formation.

The Foraminifera and ostracods at Barwick farm were studied by Cushman and Cahill (1933, U.S.G.S. Loc. 11820) and Edwards (1944) respectively. Cushman described 13 species of Foraminifera from the locality. The abundant megafossil fauna has never been described from the Barwick marl pit.

ACKNOWLEDGMENTS

This paper was completed with the aid and cooperation of a number of people.

Sincere appreciation is expressed to Doctors Joseph St. Jean, Jr., Roy L. Ingram, and Walter H. Wheeler, members of the faculty in the Department of Geology at the University of North Carolina, Chapel Hill, North Carolina. The study was done under the helpful guidance and supervision of Dr. St. Jean, who spent many hours verifying the identification of the fossils and contributed many helpful suggestions and criticisms of the paper. Dr. Ingram supplied information to facilitate the sedimentary analyses of the samples. I am indebted to Dr. Wheeler for comments concerning the stratigraphy.

C. E. Brett, F. A. Hills, S. O. Bird, and Evelyn Z. Sinha, graduate students at the University of North Carolina, assisted with the field work, and their help is greatly appreciated.

Added thanks are due C. E. Brett for collaborating in the development of a satisfactory photographic system used to photograph the Foraminifera studied.

Mr. Albert Matthews of Magnolia, North Carolina, owner of the farm where Natural Well is located, graciously allowed me to visit the site on numerous occasions and collect samples.

Mr. and Mrs. R. E. Barwick, of Magnolia, North Carolina,

kindly permitted me to collect samples from the marl pit on their farm. This outcrop was pointed out by Mr. J. G. Chestnut, son of Mr. A. R. Chestnut, the former owner of the farm.

Special thanks to my wife, Doris, for encouragement and for the clerical work necessary to complete the paper.

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METHODS OF STUDY

FIELD SAMPLING

Samples of approximately 400 grams were collected on the south side of Natural Well at 1 foot vertical intervals throughout the exposed Eocene and Miocene section. A total of 18 samples was collected from the Natural Well locality, 5 from the Duplin formation and 13 from the Castle Hayne formation. To expose a vertical section of the Duplin marl it was necessary to dig a shallow drainage ditch.

At the Barwick farm locality, one large sample of unweathered material was collected from the northwestern corner of the marl pit.

PREPARATION OF FORAMINIFERA

The Foraminifera are rare in the Duplin marl and abundant in the Castle Hayne formation. Samples from the Duplin marl, of approximately 300 grams, were treated to obtain sufficient numbers for study, whereas it was only necessary to treat 100 gram samples of material from the Castle Hayne formation to obtain adequate numbers of specimens.

The silt and clay size particles were washed from the samples using a Curtin sediment washer. The samples were dried, sieved, and the very fine-medium sand size materials were floated with carbon tetrachloride to concentrate the Foraminifera. The specimens from each concentrated sample were picked at random and placed on faunal slides from which the identifications were made.

METHODS OF IDENTIFICATION AND DESCRIPTION OF FORAMINIFERA

The identifications were made from the literature, and in all cases previously described specimens have been compared with the type figures and type descriptions. Any differences in the type specimens have been noted in the systematic descriptions. The Galloway classification has been followed in the systematic descriptions.

The dimensions of all specimens to the nearest .01 mm. are included in the descriptions. The measurements were made using a calibrated ocular reticle. The terms height, width, and thickness are used in listing the dimensions of many of the coiled forms. These terms are defined as follows: height is the distance from the top of the ultimate chamber to the base of the specimen in the plane of coiling; width is the distance across the specimen at right angles to the height in the plane of coiling; thickness is the distance across the specimen when oriented on edge and is measured at right angles to the plane of coiling. The term periphery, as used in the systematic descriptions, pertains to the edges of fossils when oriented in side view.

Counts of each species were made to determine the relative abundance. The following scales were used to express the relative abundance of each species. Two scales were used because of the difference in relative abundance of Foraminifera in each formation. These scales are not quantitative.

	Duplin marl	Castle Hayne formation
Abundant	More than 15	More than 25
Common	6-15	11-25
Rare	1- 5	1-10

SEDIMENTARY ANALYSES

Sedimentary analyses were performed on a majority of the samples to provide additional information useful in properly describing the formations studied and to obtain information useful in paleoecological interpretation. The following samples were analyzed: 3 from the Duplin marl at Natural Well, representing the top, middle, and bottom of the bed, 1 from the Duplin marl at Barwick farm, and the 13 samples from the Castle Hayne formation at Natural Well.

The following procedures were followed in analyzing the samples for the sand, silt, and clay content. The air-dried samples were weighed and soaked overnight in demineralized water containing 2 ml. of 10% "Calgon" to disperse the clay particles. The samples were wet sieved through a 250 mesh screen to separate the coarse and fine fractions. The sand size fraction of the sediments was analyzed by sieving according to the Wentworth Grade Scale and the fine fraction, by the pipette method. The samples were pipetted for the clay content, and the percentage of silt was determined by subtracting the weight of the sand and clay from the weight of the whole sample. The coarse fractions of samples from the Duplin and Castle Hayne formations were analyzed as to content by the method described by Shepard and Moore (1954, pp. 1792-1802).

The approximate carbonate percentage of Duplin samples from each locality and of seven from the Castle Hayne formation was determined by air drying, weighing, and soaking the samples in dilute hydrochloric acid until all the carbonate was dissolved. The residue was then washed, redried, and weighed. The percentage of carbonate was determined by subtracting the weight of the residue from the original weight of the sample.

PHOTOGRAPHIC PROCESS

The specimens were photographed following the procedures outlined by Fournier (1956). The equipment used to photograph the specimens is listed below:

1) Exacta XVIIa 35 mm. camera equipped with a Magnear focusing and viewing attachment
2) Exacta 15 mm. photomicrography extension tube
3) Exacta microscope adapter
4) Bausch and Lomb petrographic microscope
5) 10x and 3.5x strain-free objectives
6) 15x hyperplane ocular
7) Two Bausch and Lomb parabolic reflector microscope lamps
8) Two pinhole apertures
9) Ansco Stay-Flat solution
10) Kodak polarizing material

The 10x objective with a 690 micron pinhole aperture was used to photograph specimens not exceeding 0.60 mm. in length, and the 3.5x objective with a 1400 micron aperture was used for the larger specimens. The pinhole apertures were constructed using cardboard, sewing thread, glue, and aluminum foil. All of the specimens were photographed dry and unstained. The photographs have been retouched where necessary.

STRATIGRAPHY AND PALEONTOLOGY OF THE CASTLE HAYNE FORMATION

DEFINITION AND AREAL DISTRIBUTION

The name Castle Hayne formation was proposed by Miller (in Clark, *et al.,* 1912, p. 185) for deposits constituting the upper Eocene horizon in North Carolina, typically exposed near the town of Castle Hayne in New Hanover County, North Carolina. The formation consists principally of calcareous marls, fossiliferous limestones, and phosphate pebble conglomerates.

The Castle Hayne formation occurs as an extensive sheet deposit over large sections of the Carolina Coastal Plain where it is overlain and partially concealed by Miocene and post-Miocene sediments (LeGrand and Brown, 1955, p. 9). The main body of the formation crops out or is located near the surface in the southeastern portion of the Carolina Coastal Plain from the vicinity of the Neuse River in Craven County southwestward to Brunswick County, North Carolina. In the subsurface the formation thickens rapidly downdip (Spangler, 1950, figures 10, 11).

The formation apparently extended inland some distance beyond the present position of the main portion. This is clearly indicated by the many outliers located west of the general outcrop area, such as the one in which Natural Well is located.

LITHOLOGY OF THE CASTLE HAYNE FORMATION AT NATURAL WELL

During the dry seasons of the year 13 feet of the Castle Hayne formation are exposed above the waterline at Natural Well. The lithology of the Castle Hayne formation at this locality has been described by Huddle (1940, p. 227) as 13 feet of light green calcareous sandstones. Richards described the lithology (1950, p. 17) as a light green sand.

Sedimentary analyses performed in the course of this study indicate that three major lithologic units compose the formation at Natural Well. The lower three feet of the formation are composed of light green, poorly indurated, argillaceous, calcareous siltstones interbedded with thin lenses of indurated silty limestone less than one inch in thickness. Overlying the basal portion is an indurated silty limestone layer two feet thick. The upper eight feet of the formation are composed of light green, poorly indurated, silty limestones interbedded with thin lenses of indurated silty limestone which are less than one inch thick.

The coarse fractions of the samples are composed predominantly of microfossils and fossil fragments with only minor amounts of quartz, mica, and glauconite. The sand, silt, clay, and carbonate percentages are about equal in each of the poorly indurated units. The results of the sedimentary analyses are shown in Figure 2. The lower three feet of the formation are referred to in Figure 2 as the lower unit, and the upper eight feet are referred to as the upper unit.

The Foraminifera are most abundant in the upper six feet of the formation and decrease in abundance downward. Water seeps continually into the well from the exposed formations and possibly has leached microfossils and other forms of carbonate from the lower portions of the Castle Hayne formation.

GENERAL ASPECTS OF THE CASTLE HAYNE FAUNA

The Castle Hayne foraminiferal fauna consists mainly of rotaloid and arenaceous forms but also includes a moderate number of planktonic species. Species typical of Claiborne and Jackson age are present in the fauna with the majority of Jackson age. The abundant species occur throughout the entire exposure; therefore, all are of approximately the same age. The Castle Hayne fauna is not so well preserved as the Duplin fauna. Many of the tests have been extensively recrystallized and leached, resulting in a loss of the fine details of test structure.

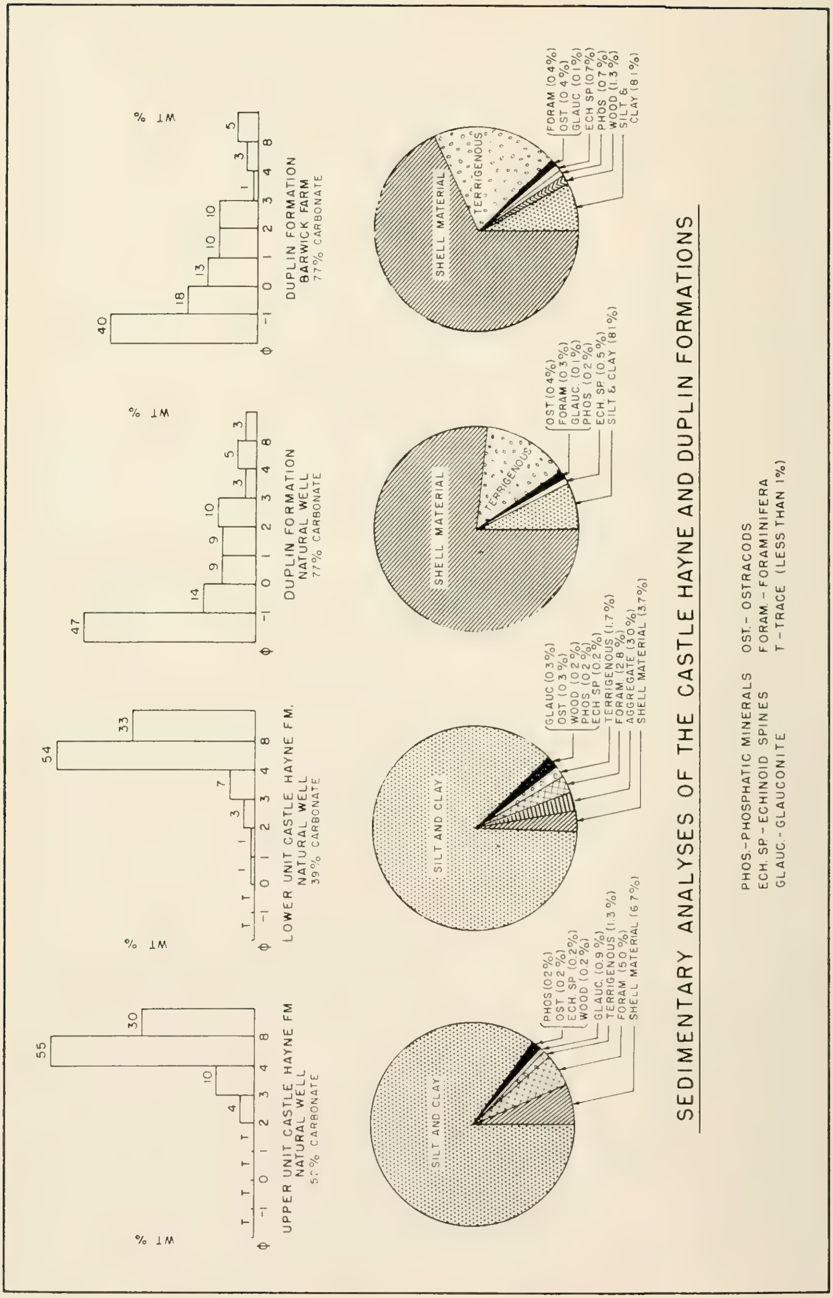

SEDIMENTARY ANALYSES OF THE CASTLE HAYNE AND DUPLIN FORMATIONS
UPPER UNIT CASTLE HAYNE FM
NATURAL WELL
59% CARBONATE
WT %
Φ
-1 0 1 2 3 4 8
T T T T 4 10 55 30
SILT AND CLAY
PHOS (0.2%)
OST (0.2%)
ECH. SP. (0.2%)
WOOD (0.2%)
GLAUC. (0.9%)
TERRIGENOUS (1.3%)
FORAM. (5.0%)
SHELL MATERIAL (6.7%)
LOWER UNIT CASTLE HAYNE FM.
NATURAL WELL
39% CARBONATE
T T T 1 1 3 7 54 33
GLAUC (0.3%)
OST (0.3%)
WOOD (0.2%)
PHOS (0.2%)
ECH SP (0.2%)
TERRIGENOUS (1.7%)
FORAM. (2.8%)
AGGREGATE (3.0%)
SHELL MATERIAL (3.7%)
DUPLIN FORMATION
NATURAL WELL
77% CARBONATE
47 14 9 9 10 3 5 3
SHELL MATERIAL
TERRIGENOUS
OST (0.4%)
FORAM (0.3%)
GLAUC. (0.1%)
PHOS (0.2%)
ECH. SP (0.5%)
SILT & CLAY (8.1%)
DUPLIN FORMATION
BARWICK FARM
77% CARBONATE
40 18 13 10 10 1 3 5
FORAM (0.4%)
OST (0.4%)
GLAUC (0.1%)
ECH SP (0.7%)
PHOS (0.7%)
WOOD (1.3%)
SILT & CLAY (8.1%)
PHOS.-PHOSPHATIC MINERALS
ECH. SP.-ECHINOID SPINES
GLAUC.-GLAUCONITE
OST.- OSTRACODS
FORAM.- FORAMINIFERA
T-TRACE (LESS THAN 1%)

Figure 2

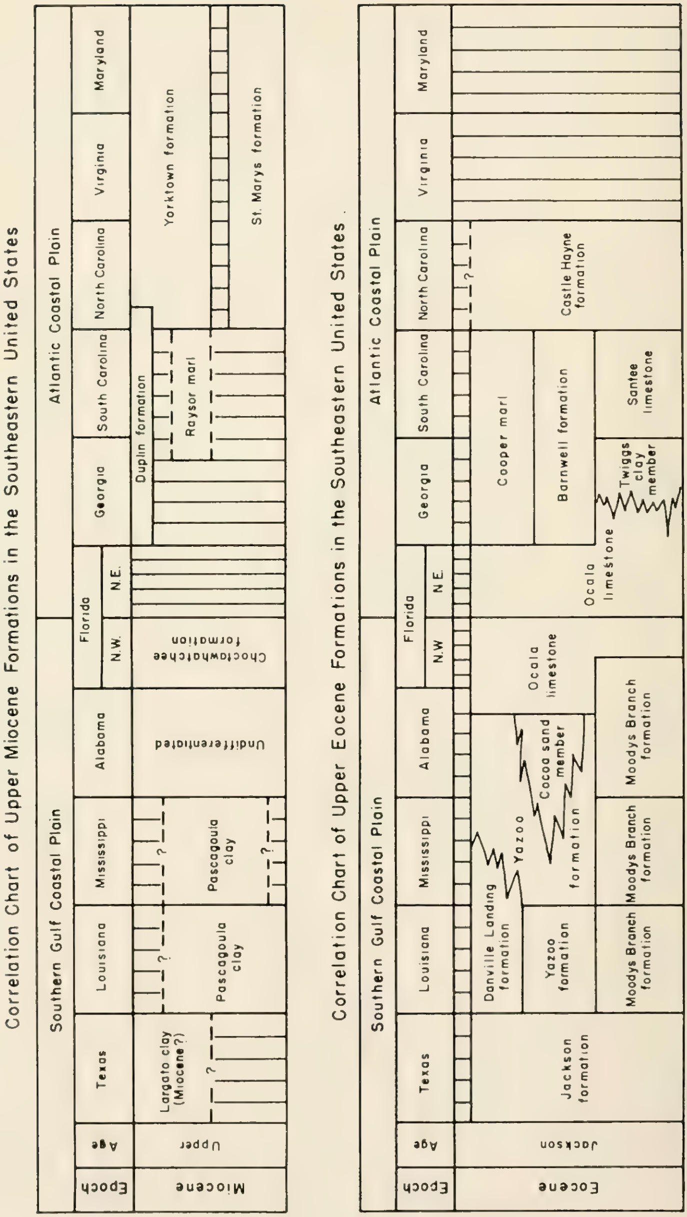
Fifty-nine species of Foraminifera have been identified from the fauna. The assemblage includes forms which have never been reported from the Eocene formations of the southeastern United States. A complete list of the previously described species is shown on the range chart and the 13 new species named from the fauna are listed.

STRATIGRAPHIC RELATIONS

At the time Miller named the Castle Hayne formation, few investigations of the faunas had been made. The formation was first assigned to the Jackson stage by Cooke (1916, p. 111). Later works on the megafossil faunas by Canu and Bassler (1920), Kellum (1926), and Richards (1950) support the Jackson age of the Castle Hayne formation and assign it further to the middle Jackson horizon of the Eocene. In recent years, LeGrand and Brown (1955) and Brown (1958) reached the conclusion that the Castle Hayne was deposited during Claiborne and Jackson time. Brown (1958), p. 6) said that "the Castle Hayne limestone was deposited during a temporal transgression from Claiborne time into Jackson time, the bulk of deposition having occurred during Jackson time." Cheetham in a short geologic note (1961, p. 395) stated, "the Castle Hayne fauna, as recognized in the classical exposures in North Carolina, lived in late Jacksonian time. Downdip, where the term "Castle Hayne" has been applied to a lithological unit in the subsurface, the contained microfauna indicates Claibornian age."

The Castle Hayne formation at Natural Well is of upper Eocene Jackson age as indicated by the ranges of the foraminiferal species (Table 2). The stratigraphic relations of the formation are shown on the correlation chart. The assemblage is composed mainly of fossils representative of the Claiborne and Jackson horizons in the Gulf Coastal Plain, and abundant forms of typical Jackson age are relatively more abundant than the typical Claiborne forms. The assemblage is more of upper lower to lower middle Jackson age.

The more abundant fossils in the formation are typical of the Yazoo and Danville Landing formations in the Gulf Coastal Plain which are of middle and upper Jackson age. The works of Bandy (1949, Tables 1, 2) and Howe and Wallace (1932) have shown that


Correlation Chart of Upper Miocene Formations in the Southeastern United States
Epoch
Age
Southern Gulf Coastal Plain
Atlantic Coastal Plain
Texas
Louisiana
Mississippi
Alabama
Florida
N.W.
N.E.
Georgia
South Carolina
North Carolina
Virginia
Maryland
Miocene
Upper
Largato clay (Miocene?)
?
Pascagoula clay
?
Pascagoula clay
?
Undifferentiated
Choctawhatchee formation
Duplin formation
Raysor marl
Yorktown formation
St. Marys formation
Correlation Chart of Upper Eocene Formations in the Southeastern United States.
Epoch
Age
Southern Gulf Coastal Plain
Atlantic Coastal Plain
Texas
Louisiana
Mississippi
Alabama
Florida
N.W
N.E.
Georgia
South Carolina
North Carolina
Virginia
Maryland
Eocene
Jackson
Jackson formation
Danville Landing formation
Yazoo formation
Moodys Branch formation
Yazoo formation
Moodys Branch formation
Cocoa sand member
Moodys Branch formation
Ocala limestone
Ocala limestone
Cooper marl
Barnwell formation
Twiggs clay member
Santee limestone
?
Castle Hayne formation

Modified after Cooke et. al. (1943), Murray (1947, p 1838) and Wilbert (1953, p 26)

Figure 3

such forms as *Valvulineria octocamerata* (Cushman and Thomas), *Siphonina danvillensis* Howe and Wallace, *Nonion danvillensis* Howe and Wallace, *Valvulineria danvillensis* (Howe and Wallace), and *Valvulineria texana* Cushman and Ellisor are especially characteristic and abundant in the Yazoo and Danville Landing formations. However, the occurrence of a few abundant typically Claiborne age fossils suggests that the Castle Hayne formation at Natural Well is slightly older than the Danville Landing formation and the upper portions of the Yazoo formation. The Castle Hayne formation at this locality is probably equivalent in age to the upper part of the Moodys Branch formation and the lower part of the Yazoo formation.

In the Cenozoic correlation chart of the formations of the Atlantic and Gulf Coastal Plain (Cooke, *et al.*, 1943), the top of the Castle Hayne formation is drawn below the base of the Yazoo formation. After further study the Castle Hayne formation may be proven to extend higher than has been previously shown; accordingly the upper limit of the Castle Hayne formation on the correlation chart is shown to be indefinite.

Correlation with other upper Eocene horizons in the Atlantic Coastal Plain is exceedingly difficult because only six of the Castle Hayne species are known to occur in these formations. A table showing the distribution of the Castle Hayne species in the upper Eocene horizons of the southeastern United States is included.

PALEOECOLOGY

The Castle Hayne foraminiferal fauna is characterized by the occurrence of abundant rotaloid and arenaceous forms typical of the open shelf environment. The benthonic genera are commonly found in Recent sediments of the Gulf of Mexico at average depths of 60-150 feet.

Planktonic forms occur commonly in the fauna but are not abundant. According to Bandy (1956, p. 187) *Globigerina bulloides* first occurs at depths of 100-160 feet in the Gulf of Mexico. Shepard and Moore (1955, p. 1539) found that, at depths beyond 120 feet in the Gulf of Mexico, the planktonic species become abundant and constitute the major portion of the samples collected.

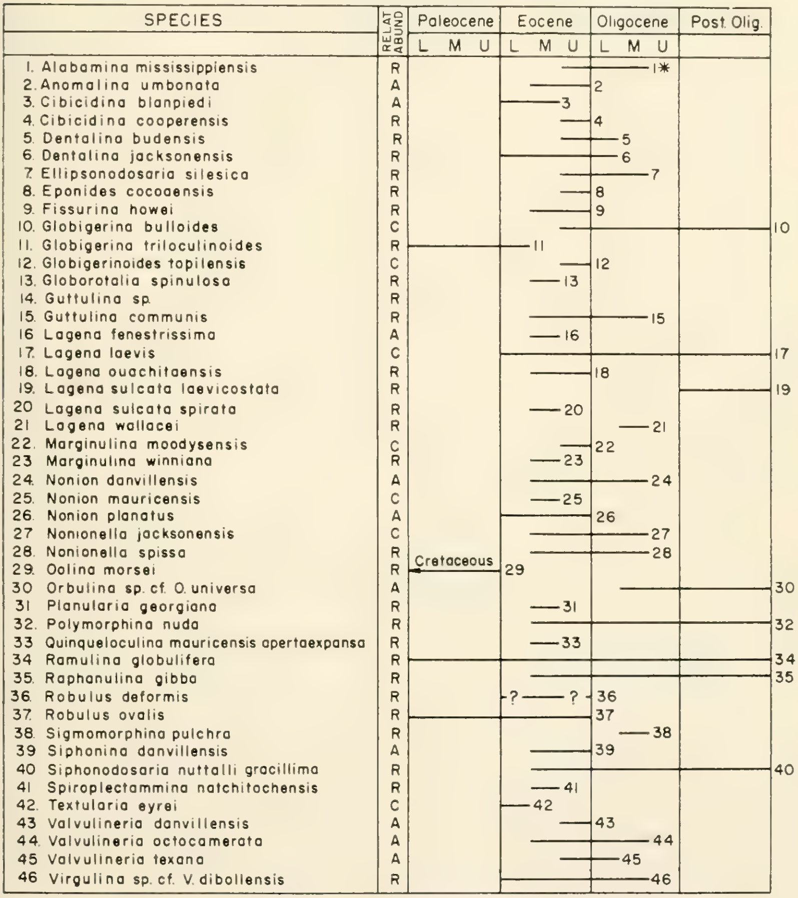
Table 1.

Distribution of Castle Hayne Species in the Upper Eocene Formations of the Southeast

			Ocala fm.		Jackson group-Ala.		Miss. La.
Species	Cooper marl S.C.	Ga.	Fla.	Ala.	Moodys Branch	Yazoo fm.	Danville Landing fm.
Anomalina umbonata					X		
Cibicidina cooperensis						X	
Dentalina hantkeni	X						
Dentalina jacksonensis				X			
Eponides cocoaensis	X		X	X		X	X
Fissurina howei					X		
Globigerina bulloides						X	X
Guttulina communis		X	X	X			X
Lagena laevis	X		X				
Lagena ouachitaensis							X
Marginulina moodysensis					X		
Nonion danvillensis						X	X
Nonion planatus			X		X	X	
Nonionella jacksonensis	X			X		X	
Nonionella spissa	X			X	X	X	
Polymorphina nuda						X	
Ramulina globulifera					X	X	
Raphanulina gibba	X	X	X	X	X	X	X
Siphonina danvillensis					X	X	X
Valvulineria danvillensis						X	X
Valvulineria octocamerata				X		X	
Valvulineria texana			X	X		X	X

Table 2

RANGE CHART OF PREVIOUSLY DESCRIBED CASTLE HAYNE SPECIES FROM NATURAL WELL



SPECIES	RELAT ABUND
1. Alabamina mississippiensis	R
2. Anomalina umbonata	A
3. Cibicidina blanpiedi	A
4. Cibicidina cooperensis	R
5. Dentalina budensis	R
6. Dentalina jacksonensis	R
7. Ellipsonodosaria silesica	R
8. Eponides cocoaensis	R
9. Fissurina howei	R
10. Globigerina bulloides	C
11. Globigerina triloculinoides	R
12. Globigerinoides topilensis	C
13. Globorotalia spinulosa	R
14. Guttulina sp.	R
15. Guttulina communis	R
16 Lagena fenestrissima	A
17. Lagena laevis	C
18. Lagena ouachitaensis	R
19. Lagena sulcata laevicostata	R
20 Lagena sulcata spirata	R
21 Lagena wallacei	R
22. Marginulina moodysensis	C
23 Marginulina winniana	R
24. Nonion danvillensis	A
25. Nonion mauricensis	C
26. Nonion planatus	A
27 Nonionella jacksonensis	C
28. Nonionella spissa	R
29. Oolina morsei	R
30 Orbulina sp. cf. O. universa	A
31 Planularia georgiana	R
32. Polymorphina nuda	R
33 Quinqueloculina mauricensis apertaexpansa	R
34 Ramulina globulifera	R
35. Raphanulina gibba	R
36. Robulus deformis	R
37. Robulus ovalis	R
38. Sigmomorphina pulchra	R
39 Siphonina danvillensis	A
40 Siphonodosaria nuttalli gracillima	R
41 Spiroplectammina natchitochensis	R
42. Textularia eyrei	C
43 Valvulineria danvillensis	A
44. Valvulineria octocamerata	A
45 Valvulineria texana	A
46 Virgulina sp. cf. V. dibollensis	R

A - Abundant
C - Common
R - Rare

* Numbers to right of ranges correspond to numerical listing of the species.

The habitat of the Castle Hayne fauna was probably the inner sublittoral zone at a depth of from 60-120 feet. The substrate, as indicated by the sedimentary data, was composed of limy silt and clay. The average carbonate percentage of 50 percent suggests that deposition took place in warmer marine waters than are now common at this latitude. This view is further substantiated by the foraminiferal fauna which has been identified mainly from the Tertiary deposits of the Gulf Coast area.

Megafossils are absent from the formation at Natural Well, except for a few juvenile gastropods and brachiopods. The absence of the megafossils is possibly explained by the substrate which had an average composition of 15 percent sand, 55 percent silt, and 30 percent clay. This constitutes an unsuitable substrate for most pelecypods, gastropods, and brachiopods. According to Day (1951, p. 63), "soft slurry muds carry a poor macrofauna, largely restricted to the surface, presumably because of the lack of oxygen in the lower layers." The depth of water is another possible explanation for the lack of megafossils.

STRATIGRAPHY AND PALEONTOLOGY OF THE DUPLIN MARL

DEFINITION, AREAL DISTRIBUTION, AND STATUS

The name Duplin formation was proposed by Dall (1898, p. 338) for the late Miocene marls of Duplin County, North Carolina. The formation consists of unconsolidated sands, arenaceous clays, and shell marls which represent the latest phase of Miocene deposition in the region south of the Neuse River (Miller 1912, p. 237). A type locality of the Duplin marl has never been designated, but the outcrop in the Natural Well near Magnolia, North Carolina, is generally considered to be the type locality. The Duplin marl crops out mainly in the southwestern corner of Duplin County as a narrow belt approximately 15 miles in length. Small outliers of the formation occur in Sampson, Bladen, Pender, Columbus, and Wayne counties. North of the Neuse River, the upper Miocene deposits are referred to the Yorktown formation.

The status of the Duplin marl as a valid formation has been questioned by LeGrand and Brown (1955, p. 11), who are of the opinion that the Duplin is a shallow water facies of the Yorktown and not a separate formation. The argument of LeGrand and Brown is based on the following reasons: 1) subsurface and surface evidence south of the Neuse River indicate the Duplin marl is confined to updip sections and outcrops, and 2) similarity of the Duplin and Yorktown microfaunas. Brown has based the faunal conclusions mainly on ostracods.

Dawson (1958, p. 4), in a comparative study of Duplin and Yorktown megafossils from North Carolina, said that the differences in lithology and fauna make it unlikely that the two belong in a single formation.

The present study adds little additional information concerning the validity of the Duplin marl as a separate formation. The limited stratigraphic scope of this paper and the lack of detailed studies of the North Carolina Yorktown foraminiferal faunas prevents a direct comparison of the Yorktown and Duplin faunas. Cushman and Cahill (1933) described 28 species of Foraminifera from the Yorktown formation in North Carolina, only 7 of which occur in the Duplin marl at the 2 localities studied.

DUPLIN MARL AT NATURAL WELL

The Duplin marl at Natural Well unconformably overlies the Castle Hayne formation and is exposed on the south and west sides of the well. Immediately overlying the Duplin formation are 10 feet of supposed Pleistocene silty sand.

The formation consists of 3-5 feet of whole shells and fragmentary shells in a matrix of silty sand. Phosphate pebbles and cobbles occur near the base of the formation. Fresh exposures of the formation are medium blue-gray in color. The coarse fraction of the sediment consists primarily of shells and shell fragments with minor amounts of microfossils, quartz grains, quartz pebbles, garnet, plant fibers, and phosphate nodules of varying sizes. The results of the sedimentary analyses are shown on Figure 2.

DUPLIN MARL AT BARWICK FARM

Five feet of the Duplin marl are exposed above the water line in the marl pit on the Barwick farm. Fresh, unweathered material. medium blue-gray in color, is obtainable near the base of the exposure. The formation consists of whole shells and shell fragments in a matrix of clayey sand, with minor amounts of quartz, glauconite, plant fibers, microfossils, and phosphate nodules. The phosphatic materials vary considerably in size. The Duplin marl is overlain by approximately three feet of silty sand of probable Pleistocene age.

The lithology of the Duplin marl at Barwick farm differs slightly from the exposure at Natural Well in the higher clay content and lower percentage of shell material. The results of the sedimentary analyses are shown on Figure 2.

GENERAL ASPECTS OF THE DUPLIN FAUNA

The Duplin foraminiferal faunas at the two localities studied are composed mainly of benthonic forms with a minor representation of planktonic species. The Foraminifera, in general, are in an excellent state of preservation with only a few showing the effects of leaching and infiltration. The previously described species are wide ranging geographically throughout the middle and upper Miocene formations of the Atlantic Coastal Plain and Florida. Foraminifera are rare at both localities but do occur in slightly greater numbers at the Barwick farm locality.

The Duplin marl microfauna includes 44 species of Foraminifera, 10 of which are named in this report. A complete list of the previously described species is shown on the range chart. A separate list of the new species is included.

STRATIGRAPHIC RELATIONS

The Duplin marl has been considered to be equivalent in age to the uppermost portion of the Yorktown formation (Zone 2) by Mansfield (in Gardner 1943, p. 13). Dawson (1958, p. 69) agreed with the correlation of Mansfield and concluded further that the Duplin fauna also correlates with the *Cancellaria* zone of the Choctawhatchee formation of Florida. The *Cancellaria* zone represents the uppermost portion of the Choctawhatchee and is of upper Miocene age.

The Duplin marl contains 44 species of Foraminifera (total from both localities); of these, 24 species occur either in the Yorktown formation of Virginia or the Choctawhatchee formation of Florida. Forty-six percent of the species occur in both the Yorktown and Choctawhatchee, 33 percent occur only in the Choctawhatchee and the remaining 21 percent occur only in the Yorktown formation. The Duplin fauna is slightly more similar to the Choctawhatchee foraminiferal assemblage. If the analyses of other workers are correct, the Duplin formation is equivalent to uppermost Yorktown and Choctawhatchee.

A precise correlation within the faunal zones of both formations is difficult for the following reasons: 1) the ranges of the Yorktown foraminiferal species within the faunal zones of the formation have not been accurately determined; 2) the Duplin foraminiferal fauna is most similar to diagnostic Choctawhatchee species common among all four facies of the formation (Puri, 1953, p. 50); 3) at the present time it is necessary to carry correlations over long distances; and 4) the Duplin foraminiferal fauna is composed of only 44 species, 10 of which are new species.

A table showing the occurrence of the 24 previously described foraminiferal species common to the Yorktown and Choctawhatchee formations is included.

PALEOECOLOGY

The abundant benthonic species in the Duplin formation are *Cibicides americanus, Cibicides duplinensis, Discorbis duplinensis, Planorbulinella perforata, Streblus beccarii parkinsoniana,* and several species of *Elphidium* which collectively are abundant. The only abundant planktonic form in the fauna is *Globigerinoides rubra,* but other planktonic species do occur.

Studies of Recent faunas from the northeastern Gulf of Mexico by Bandy (1956, p. 185) indicate that *Streblus* and *Elphidium* are especially characteristic of shallow water in the 8-40 foot depth range. The other benthonic species in the Duplin faunas are characteristic of ocean depths in excess of 40 feet. According to Bandy (1956, p. 187), *Globigerinoides rubra* is the first of the planktonic species to appear in shallow water transects and then at depths of from 70-100 feet. The foraminiferal fauna seems to be transitional between a true shallow water fauna (above wave base) and those located in slightly deeper water (below wave base). There is no essential difference in the foraminiferal faunas at either locality, and there is no evidence to indicate the transportation of the typically shallow water components (*Streblus* and *Elphidium*) into deeper waters.

Table 3

Duplin Marl Species Occurring in the
Yorktown and Choctawhatchee Formations

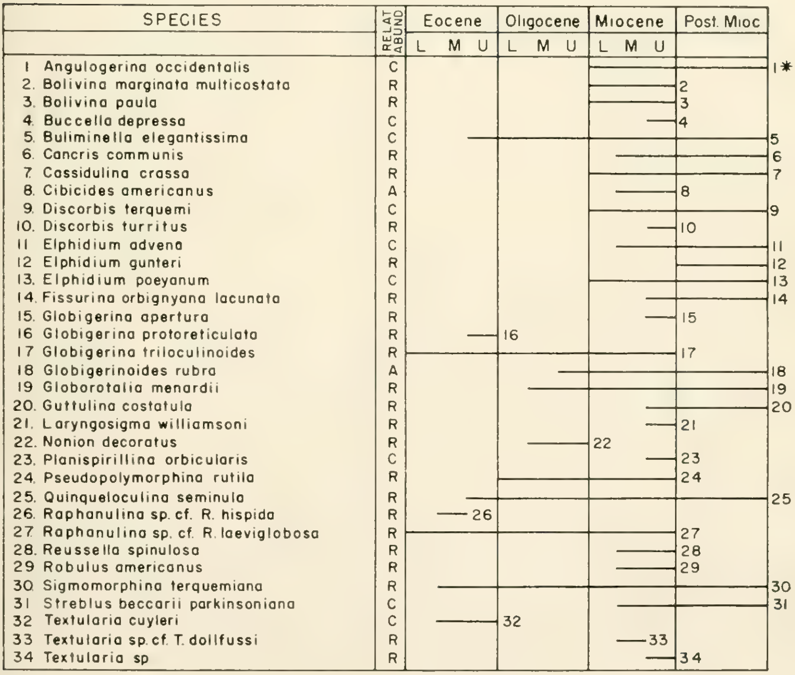
Species	Yorktown formation	Choctawhatchee formation
Angulogerina occidentalis	X	X
Bolivina marginata multicostata		X
Bolivina paula		X
Buccella depressa	X	
Buliminella elegantissima	X	X
Cancris communis	X	X
Cassidulina crassa	X	X
Cibicides americanus	X	X
Discorbis terquemi		X
Discorbis turritus	X	
Elphidium advena	X	X
Elphidium poeyanum		X
Fissurina orbignyana lacunata		X
Globigerina apertura	X	
Globorotalia menardii		X
Guttulina costatula		X
Laryngosigma williamsoni	X	
Planispirillina orbicularis	X	X
Pseudopolymorphina rutila	X	X
Quinqueloculina seminula	X	X
Reussella spinulosa	X	X
Robulus americanus		X
Sigmomorphina terquemiana	X	
Streblus beccarii parkinsoniana		X

The prolific Duplin marl molluscan assemblage is characteristic of warm shallow water and consists of complete and fragmentary specimens. There is no evidence to indicate transportation of the assemblage for any great distance, because the shells and fragments do not show the effects of abrasion and the structural details have not been obscured. The shells were probably broken by storm waves. Wave base, during storms, may extend to 30-40 feet in depth according to Shepard (1948, p. 47).

The habitat of the Duplin fauna was apparently the inner sublittoral zone (Hedgpeth, 1957, p. 18) at a water depth of from 30-60 feet. The sedimentary data indicate that during upper Miocene time the Duplin faunas lived on and within a silty sand substrate.

Table 4

RANGE CHART OF PREVIOUSLY DESCRIBED DUPLIN MARL SPECIES FROM NATURAL WELL AND BARWICK FARM.



A-Abundant
C-Common
R-Rare

* Numbers to right of ranges correspond to numerical listing of the species.

SUMMARY

1. The paper includes descriptions and figures of 103 species of upper Eocene and upper Miocene Foraminifera.
2. Thirteen new species have been named from the Castle Hayne formation and 10 new species have been named from the Duplin formation.
3. The lectotype for *Sigmomorphina terquemiana* (Fornasini) has been designated.
4. The Castle Hayne formation at Natural Well is composed of silty limestones and argillaceous siltstone.
5. The Castle Hayne formation at Natural Well is of upper lower to lower middle Jackson age and is probably equivalent to the upper portions of the Moodys Branch formation and lower portions of the Yazoo formation in the Gulf Coastal Plain.
6. The Duplin marl is composed of shells and shell fragments in a matrix of silty sand at Natural Well, and a matrix of clayey sand encloses the shells and shell fragments at Barwick farm.
7. The Duplin marl correlates with the Yorktown formation of Virginia and the Choctawhatchee formation of Florida.
8. The Duplin foraminiferal faunas contain more Choctawhatchee species than Yorktown species.
9. The habitat of the Castle Hayne fauna was probably the inner sublittoral zone at a depth of from 60-120 feet.
10. The habitat of the Duplin fauna was probably the inner sublittoral zone at a water depth of from 30-60 feet.

SYSTEMATIC DESCRIPTIONS

The type specimens have been deposited in the Paleontology Laboratory of the University of North Carolina, Department of Geology at Chapel Hill, North Carolina. University of North Carolina catalog numbers have been assigned to all the specimens and are shown in the systematic descriptions.

Family **SPIRILLINIDAE** Reuss, 1861

Genus **PLANISPIRILLINA** Bermudez, 1952

Planispirillina orbicularis (Bagg) Pl. 34, figs. 6a-c

Spirillina orbicularis Bagg, 1898, Bull. Amer. Paleont., vol. 2, No. 10.

p. 33, pl. 2 (22), figs. 2a-c; Cushman, 1918, U.S. Geol. Sur., Bull. 676, p. 58, pl. 14, fig. 1; Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 51, pl. 9, figs. 12a, 12b.

Planispirillina orbicularis Puri, 1953, Florida Geol. Sur., Bull. 36, p. 130, pl. 20, figs. 1, 2; McLean, 1956, Bull. Amer. Paleont., vol. 36, No. 160, p. 351, pl. 46, figs. 7-8.

Test planispiral, consisting of four whorls, convexo-concave, periphery broadly rounded, ventral side with rows of beads partially obscuring the whorl sutures, dorsal side convex, inner margins of the sutures serrate, with a single large pore between each serration; wall calcareous, imperforate, except for inner marginal perforations, porcellaneous in appearance; aperture terminal, a high arch, restricted and not of full tubular diameter. Diameter, 0.28 mm.; thickness, 0.09 mm.

Common. Duplin marl, at Natural Well and Barwick farm.

Species collected from the Duplin marl apparently are better preserved than those reported by Bagg, Cushman, Puri, and McLean and seem to have dominantly a dextral coil. The specimens are from 0.25 mm.—0.42 mm. in diameter with the other characters remaining constant.

Plesiotype.—U.N.C. Cat. No. 3479.

Family **MILIOLIDAE** d'Orbigny, 1839

Genus **QUINQUELOCULINA** d'Orbigny, 1826

Quinqueloculina mauricensis apertaexpansa Bandy Pl. 23, figs. 1a-c

Quinqueloculina mauricensis apertaexpansa Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 20, pl. 1, figs. 9a-c.

Test slightly more than twice as long as wide, the apertural end produced, subtriangular in apertural view, periphery with distinct narrow keels; chambers distinct, inflated, triangular in cross section; sutures distinct, depressed; wall porcellaneous; aperture terminal, round, with a distinct small lip and simple tooth at the end of a slightly flaring neck. Length, 0.43 mm.; width, 0.20 mm.; thickness, 0.15 mm.

Rare. Castle Hayne formation, at Natural Well.

The specimens are poorly preserved, grossly recrystallized, and show only minor variation except for size. The forms range from 0.39 mm.—0.62 mm. in length and differ from the type figure in being appreciably smaller.

Plesiotype.—U.N.C. Cat. No. 3435.

Quinqueloculina seminula (Linné) Pl. 34, figs. 7a-c

Serpula seminulum Linné, 1758, Systema Naturae, 10th ed., vol. 1, p. 786, pl. 2, figs. 1a-c.
Quinqueloculina seminulum d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 303.
Miliolina seminulum Brady, 1884, *Challenger* Rept., Zoology, vol. 9, p. 157, pl. 5, fig. 6.
Quinqueloculina seminulum Cushman, 1918, U.S. Nat. Mus., Bull. 103, p. 78, pl. 27, figs. 4a, 4b; pl. 28, figs. 1-3; pl. 29, figs. 1a-3; Cushman, 1918, U. S. Geol. Sur., Bull. 676, p. 22, 70, pl. 1, fig. 8; pl. 28, figs. 2, 4, 5; pl. 29, fig. 1; Cushman, 1929, U. S. Nat. Mus., Bull. 104, pt. 6, p. 24, pl. 2, figs 1, 2.
Quinqueloculina seminula Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 19, pl. 2, figs. 1, 2; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 9, pl. 2, figs. 2a-c
Quinqueloculina seminulum Bermudez, 1949, Cushman Lab. Foram. Res., Special Pub. 25, p. 102, pl. 6, fig. 6.
Quinqueloculina seminula Puri, 1953, Florida Geol. Sur., Bull. 36, pp. 86, 87.

Test longer than wide, greatest width near the middle, periphery broadly rounded; chambers distinct, inflated, of uniform character; sutures distinct, depressed; wall smooth, porcellaneous, imperforate; aperture terminal, large, subcircular with a prominent simple tooth. Length, 0.48 mm.; width, 0.24 mm.; thickness, 0.18 mm.

Rare. Duplin marl, at Natural Well only.

The specimen may be different from Linné's original, though similar, and is identical to what others have commonly considered *Q. seminula*. It is further possible that those from the Miocene are not conspecific with the Recent representatives of the species.

Plesiotype.—U.N.C. Cat. No. 3483.

Family **TEXTULARIIDAE** d'Orbigny, 1846

Genus **SPIROPLECTAMMINA** Cushman, 1927

Spiroplectammina angulomarginata, new species Pl. 23, figs. 2a-b

Textularia mississippiensis alabamensis Cushman, 1935 (not Cushman, 1923), U. S. Geol. Sur., Prof. Paper 181, p. 7, pl. 1, figs. 5, 6.
Spiroplectammina mississippiensis alabamensis Cushman and Herrick, 1945 (not Cushman, 1923), Contr. Cushman Lab. Foram. Res., vol. 21, pt. 3, p. 56, pl. 9, figs. 1-3; Cushman and Todd, 1945 (not Cushman, 1923), *ibid.*, pt. 4, p. 80, pl. 13, fig. 2; Cushman and Todd, 1945 (not Cushman, 1923), *ibid.*, vol. 22, p. 76, pl. 13, fig. 11.
Spiroplectammina alabamensis Stuckey, 1946 (not Cushman, 1923), Jour. Paleont., vol. 20, p. 164, pl. 29, figs. 4, 5.

Test elongate, moderately wide, thickest in the middle, periphery acute with a narrow distinct keel; chambers numerous, about nine pairs compose the test, increasing rapidly in height as added, the early coiled portion is greatly reduced; sutures curving slightly downward at the periphery, flush with the surface, indistinct in the early portion of the test, becoming distinct, depressed in the later portion; aperture a small high arch at the base of the apertural face. Length, 0.46 mm.; width, 0.33 mm.; thickness, 0.15 mm.

Abundant. Castle Hayne formation, at Natural Well.

The species occurs abundantly throughout the formation with a considerable amount of variation in size, amount of taper, and in some the periphery is more lobulate. The forms range from 0.33 mm.—0.57 mm. in length, from 0.27 mm.—0.39 mm. in width, from 0.13 mm.—0.17 mm. in thickness, with from 7-9 pairs of chambers. The early coiled portion of many of the specimens is difficult to see.

The type figure of *Spiroplectammina alabamensis* (Cushman) (1923, U. S. Geol. Sur., Prof. Paper 133, p. 17, pl. 1, fig. 4) is difficult to use for identification purposes because the type figure illustrates a keel which completely covers the apertural face, the aperture is not described, nor figured, and the early coiled portion is not mentioned. The Castle Hayne specimens are conspecific with forms identified by Cushman, *et. al.*, as *S. alabamensis,* but because of the difficulties associated with the type figure of *S. alabamensis,* the name, *S. angulomarginata,* is proposed for the Castle Hayne species.

The specimen figured by Stuckey (see reference in the synonymy) appears to have flanged sutures instead of the depressed sutures characteristic of the species. Stuckey's description of the species, however, mentions the depressed sutures, and so it is included in *Spiroplectammina angulomarginata.*

Spiroplectammina angulomarginata may be distinguished from *S. alabamensis diminutiva* Bandy (1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 33, pl. 4, fig. 8) by the well-developed keel, relatively indistinct, straighter sutures, more numerous chambers, and relatively thinner test.

Holotype.—U.N.C. Cat. No. 3445.

Spiroplectammina natchitochensis Howe Pl. 23, figs. 3a-b

Spiroplectammina natchitochensis Howe, 1939, Louisiana Dept. Cons., Geol. Bull. 14, p. 31, pl. 1, figs. 6, 7.

Test elongate, tapering, oval in transverse section; chambers closely appressed, indistinct, planispirally coiled in the early portion, becoming biserial, increasing rapidly in size as added; sutures indistinct, flush, only slightly curved; wall coarsely arenaceous obscuring test detail; aperture an elongate narrow slit at the base of the last chamber. Length, 0.69 mm.; width, 0.48 mm.; thickness, 0.34 mm.

Rare. Castle Hayne formation, at Natural Well.

This species occurs in only one sample and differs from the type figure in the larger, nonlipped aperture, coarsely granular apertural face, more numerous chambers, larger size, and oval apertural profile.

Plesiotype.—U.N.C. Cat. No. 3446.

Genus **SIPHOTEXTULARIA** Finlay, 1939

Siphotextularia breviforma, new species Pl. 23, figs. 4a-b

Test stout, tapering gradually from the apertural to the blunt initial end, periphery broadly rounded, slightly lobulate; chambers few, indistinct in the early portion, four pairs visible, enlarging rapidly in size; sutures indistinct in the early portion, slightly curved and depressed in the later portion; wall finely arenaceous with much cement; aperture small, elliptical, with a slight lip, located at the end of a short neck near the base of the septal face. Length, 0.45 mm.; width, 0.26 mm.; thickness, 0.20 mm.

Common. Castle Hayne formation, at Natural Well.

The specimens range from 0.33—0.51 mm. in length; from 0.21—0.30 mm. in width and from 0.18—0.22 mm. in thickness. The tests are composed of from 4-5 pairs of chambers and in a few specimens the aperture is located slightly higher on the septal face. The early portions of the specimens are planispirally coiled, but this feature may be seen only in thin section.

Siphotextularia subcylindrica Finlay (1940, Roy. Soc. New Zealand, Trans. Proc., vol. 69, pt. 1, p. 449, pl. 62, figs. 9-10) differs from *S. breviforma* in the subparallel sides, subtriangular terminal chambers, more numerous chambers, and larger size. *Siphotextularia rolshauseni* Phleger and Parker (1951, p. 4, pl. 1, figs. 23-24) differs from *S. breviforma* in the lower chambers, thinner test, and nearly horizontal, more depressed sutures.

Holotype.—U.N.C. Cat. No. 3444.

Genus **TEXTULARIA** Defrance, 1824

Textularia concisa, new species Pl. 23, figs. 5a-b

Test short, stout, thick, increasing rapidly from an acute initial end to a broad apertural end, periphery subacute, oval in apertural view; chambers few, about six pairs compose the test, low, indistinct in the early portion, becoming slightly inflated, distinct in the later portion, the last two pair equal one-half the test length; sutures slightly curved, indistinct in the early portion, slightly depressed, distinct, in the mature portion; wall fine to medium coarsely arenaceous; aperture a medium arch at the base of the last chamber. Length, 0.41 mm.; width, 0.30 mm.; thickness, 0.24 mm.

Common. Castle Hayne formation, at Natural Well.

The species occurs in the upper seven feet of the formation with only slight variation. Specimens range from 0.28 mm.—0.41 mm. in length and from 0.24 mm.—0.30 mm. in width.

T. concisa differs from *T. hannai* Davis (1941, p. 149) in the subacute periphery, shorter test, lower chambers, and smaller size; from *T. cuyleri* Davis (1941, p. 147) in the acute initial end, narrower test, and more numerous chambers.

Holotype.—U.N.C. Cat. No. 3447.

Textularia cuyleri Davis Pl. 34, figs. 8a-b

Textularia cuyleri Davis, 1941, Jour. Paleont., vol. 15, p. 147, pl. 24, figs. 3, 4.

Textularia cuyleri (?) Bergquist, 1942, Mississippi Geol. Sur., Bull. 49 (Fossils), p. 11, pl. 1, figs. 10a, 10b.

Textularia cuyleri Cushman and Herrick, 1945, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 3, p. 57, pl. 9, fig. 6.

Test short, stout, increasing rapidly from a blunt pointed apex to a broad apertural end, periphery rounded; chambers few, low, nine composing the test, increasing rapidly in size as added; sutures slightly depressed, curving slightly toward the periphery; wall arenaceous; aperture a low arch at the base of the last chamber.

Length, 0.39 mm.; width, 0.37 mm.; thickness, 0.21 mm.

Common at Natural Well and rare at Barwick farm. Duplin marl.

The Duplin specimens differ from the type in being less broad with a more acute periphery in apertural view. All previous reported specimens are from the Jackson stage of the Eocene.

Plesiotype.—U.N.C. Cat. No. 3489.

Textularia sp. cf. **T. dollfussi** Lalicker Pl. 34, figs. 9a-b

Textularia dollfussi Lalicker, 1935, Contr. Cushman Lab. Foram. Res., vol. 11, p. 45, pl. 7, figs. 8, 9.

Test compressed, broad at the apertural end, periphery broadly rounded; chambers distinct, five pairs visible, slightly inflated, the last two greatly enlarged; sutures depressed, gently curved; wall coarsely arenaceous; aperture a low arched slit at the base of the last chamber. Length, 0.60 mm.; width, 0.45 mm.; thickness, 0.25 mm.

Rare. Duplin marl, at Natural Well and Barwick farm.

The specimens found are damaged and an exact determination cannot be made. They differ from the type figure in the gently curved sutures, thinner test, more lobulate periphery, higher terminal chamber, and appreciably smaller size.

Plesiotype.—U.N.C. Cat. No. 3490.

Textularia eyrei Finlay Pl. 23, figs. 6a-b

Textularia eyrei Finlay, 1947, New Zealand Jour. Sci. Tech., sec. B, vol. 28, No. 5, p. 266, pl. 1, figs. 13-17.

Test large, stout, enlarging rapidly from a pointed apex to a broad apertural end, periphery highly irregular, acute; chambers low, about seven pairs compose the test, closely appressed, with irregular margins; sutures broad, limbate, curving sharply in the middle of the test and less sharply at the periphery; wall coarsely arenaceous with much cement; aperture a large low arch at the base of the last chamber. Length, 0.72 mm.; width, 0.54 mm.; thickness, 0.42 mm.

Common. Castle Hayne formation, at Natural Well.

This species is present only in the upper six feet of the formation and varies greatly in size from 0.51 mm.—1.14 mm. in length. Some of the specimens do not taper from the initial to the apertural end but have parallel sides throughout the mature portion. The specimens are smaller than the holotype and lack the double rows of irregular nodules near the periphery, mentioned in the type description.

Plesiotype.—U.N.C. Cat. No. 3448.

Textularia megaloculata, new species Pl. 35, figs. 1a-b

Textularia gramen Cushman, 1930 (not d'Orbigny, 1846), Florida Geol. Sur., Bull. 4, p. 17, pl. 1, figs. 5a, 5b; Puri, 1953 (not d'Orbigny, 1846), Florida Geol. Sur., Bull. 36, p. 81, pl. 30, figs. 7, 8.

Test stout, large, increasing rapidly from a pointed apex to a broad apertural end, periphery round acute to rounded; chambers few, slightly inflated, about 11 composing the test, the last two large; sutures distinct, depressed, curving toward the periphery; wall medium to coarsely arenaceous; aperture large, a low arched slit at the base of the last chamber. Length, 0.75 mm.; width, 0.54 mm.; thickness, 0.30 mm.

Common. Duplin marl, at Natural Well and Barwick farm.

The specimens vary greatly in size from 0.41 mm.—0.87 mm. in length, from 0.38 mm.—0.57 mm. in width, from 0.22 mm.—0.30 mm. in thickness, with from 11—14 chambers. The degree of taper from the apex to the apertural end is greater in a few specimens. The distinctive characters of this species are the downward curving sutures which are oblique in the immature portion, decreasing in obliquity toward the mature portion, and the greatly enlarged last two chambers.

Textularia megaloculata may be distinguished from *T. gramen* d'Orbigny (1846, Foraminifères fossiles du bassin tertiaire de Vienne, p. 248, pl. 15, figs. 4-6) by the more rounded periphery, smaller size, more strongly curved sutures, and larger ultimate chambers. If the type description of D'Orbigny is correct, *T. gramen* belongs in the genus *Bolivina* because D'Orbigny described the test as punctate. Other specimens reported from the upper Miocene strata of the Atlantic Coastal Plain as *T. gramen* d'Orbigny (Cushman and Cahill, 1933, p. 7 and McLean, 1956, p. 319) are not conspecific with *T. megaloculata* and differ markedly from the type figure of *T. gramen* d'Orbigny.

Textularia megaloculata may be distinguished from *T. astutia*

Lalicker and McCulloch (1940, Southern California, Univ. Publ., Allan Hancock Pacific Exped., vol. 6, No. 2, p. 119, pl. 13, fig. 4) by the thicker test, more rounded periphery, larger ultimate chambers, and more strongly curved sutures.

Holotype.—U.N.C. Cat. No. 3491.

Textularia sp. Pl. 35, figs. 2a-b

Test large, thick, tapering, periphery rounded, oval in apertural view; chambers low, distinct, increasing rapidly in size as added, the last two greatly enlarged; sutures straight, distinct, slightly depressed; wall coarsely arenaceous; aperture a large, wide slit at the base of the apertural face. Length 0.54 mm.; width 0.40 mm.; thickness 0.27 mm.

Rare. Duplin marl at Natural Well only.

The specimens found are incomplete but apparently have not been described. Insufficient numbers and incomplete specimens prevent the naming of this species. The specimens most closely resemble *Textularia dollfussi* Lalicker (1935, Contr. Cushman Lab. Foram. Res., vol. 11, p. 45, pl. 7, figs. 8, 9). The Duplin marl specimens differ from the type figure of *T. dollfussi* and from specimens compared with *T. dollfussi* from this fauna in the smaller size, narrower test, more angled terminal chambers, and the last few chambers are higher than wide.

Plesiotype.—U.N.C. Cat. No. 3492.

Family **NODOSARIIDAE** Schultze, 1854

Genus **ASTACOLUS** Montfort, 1808

Astacolus magnoliaensis, new species Pl. 24, figs. 1a-b

Test compressed, sides nearly parallel in edge view, with a large proloculus, periphery smooth, subacute, with a narrow keel, chambers closely appressed, rapidly enlarging, six in the last whorl, the last two slightly inflated and beginning to uncoil; sutures strongly curved, beaded in the early portion, becoming strongly limbate, raised, and slightly curved in the later portion; wall hyaline, with medium fine perforations; apertural face long, flat, extending downward almost to the proloculus, aperture erect, at the top of the apertural face, large, round, radiate. Length, 0.44 mm.; width, 0.25 mm.; thickness, 0.15 mm.

Abundant. Castle Hayne formation, at Natural Well.

Astacolus magnoliaensis occurs throughout the formation with only minor variation. The specimens range from 0.39 mm.—0.48 mm. in length with from six—eight chambers, six being the most common. Beaded sutures are not common to all specimens. This feature is lacking in a few individuals and varies widely in the degree of development. The tendency toward uncoiling is greater in a few specimens causing the base of the apertural face to be slightly removed from the proloculus.

This species resembles *A. vaughani* (Cushman) (1918, U. S. Nat. Mus., Bull. 103, p. 61, pl. 22, fig. 3) but differs in the smaller size, fewer chambers, large proloculus, and erect aperture. *Astacolus brantlyi* (Garrett) (1941, Jour. Paleont., vol. 15, p. 154, pl. 26, figs. 1-4) differs from *A. magnoliaensis* in the larger size, spinose projections on the sutures in the early portion, prominent beading on the sutures, and more strongly raised sutures.

Holotype.—U.N.C. Cat. No. 3397.

Genus **PLANULARIA** Defrance, 1826

Planularia sp. cf. **P. georgiana** Cushman and Herrick Pl. 24, figs. 2a-b

Planularia georgiana Cushman and Herrick, 1945, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 3, p. 57, pl. 9, figs. 7a, 7b.

Test small, strongly compressed, periphery round in the later portion, subacute, with a narrow keel in the early portion; chambers closely coiled in the early portion beginning to uncoil in the later portion, flat, increasing in length as added, seven in the last whorl; sutures raised in the early portion, strongly curved, becoming flush with the surface and slightly curved in the adult portion; wall hyaline, medium perforate; aperture terminal, radial. Height, 0.36 mm.; width, 0.24 mm.; thickness, 0.09 mm.

Rare. Castle Hayne formation, at Natural Well.

The two specimens found range from 0.36 mm.—0.49 mm. in height and differ from the type figure in the keeled early portion, smaller size, and raised sutures restricted to the first few chambers. Both specimens are poorly preserved, and the surface of the figured specimen is coated with calcite particles which obscure detail and account for its irregular periphery.

Plesiotype.—U.N.C. Cat. No. 3433.

Genus **MARGINULINA** d'Orbigny, 1826

Marginulina moodysensis Cushman and Todd Pl. 24, fig. 3

Marginulina moodysensis Cushman and Todd, 1945, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 4, p. 85, pl. 14, figs. 1, 2.

Test elongate, slightly compressed, outer peripheral margin strongly lobulate, inner peripheral margin slightly lobulate; chambers inflated, six compose the test, increasing rapidly in height as added, initial chamber large, spherical with a short spine; sutures distinct, depressed, slightly curved, nearly horizontal; wall hyaline, finely perforate, ornamented with about 16 prominent unevenly spaced costae which extend from the base to near the top of the last chamber; aperture peripheral, oblique, round, radiate, at the end of a short neck. Length, 0.82 mm.; width, 0.23 mm.

Common. Castle Hayne formation, at Natural Well.

This species occurs throughout the formation and ranges from 0.60 mm.—0.84 mm. in length with from five—eight chambers, six being the most common. A few specimens are slightly curvilinear, and not all have the basal spine.

The forms differ from the type figure in the larger size and more numerous costae but otherwise are similar. *Marginulina moodysensis* Cushman and Todd is distinguished from *M. cocoaensis* Cushman (1925, Contr. Cushman Lab. Foram. Res., vol. 1, p. 67, pl. 10, figs. 9, 10) by the depressed sutures, lobulate periphery, smaller size, and less prominent costae.

Plesiotype.—U.N.C. Cat. No. 3423.

Marginulina winniana Howe Pl. 24, fig. 4

Marginulina winniana Howe, 1939, Louisiana Dept. Cons., Geol. Bull. 14, p. 43, pl. 6, figs. 8, 9.

Test elongate, slightly compressed, periphery slightly lobulate, gently rounded; chambers few, slightly inflated, four in number, initial chamber large, spherical; sutures distinct, oblique, depressed; wall hyaline, finely perforate, ornamented with about 14 prominent costae which extend from the initial chamber to the base of the last chamber; aperture peripheral, vertical, round, radiate, at the end of a short neck. Length, 0.45 mm.; width, 0.19 mm.

Rare. Castle Hayne formation, at Natural Well.

The species range from 0.45 mm.—0.60 mm. in length and a few have five chambers; otherwise, they are similar to the type figure. *Marginulina winniana* Howe is similar to *M. moodysensis* Cushman and Todd (described on p. 52) but is easily distinguished by the smaller size, less lobulate periphery, fewer chambers, fewer costae, and the erect or vertical aperture.

Plesiotype.—U.N.C. Cat. No. 3424.

Genus **OOLINA** d'Orbigny, 1839

Oolina morsei (Kline) Pl. 24, figs. 5a-b

Entosolenia morsei Kline, 1943, Mississippi Geol. Sur., Bull. 53, p. 48, pl. 4, fig. 17.

Test globular, round in apertural view, with a short, blunt, apical spine; surface smooth; wall hyaline, finely perforate; aperture terminal, round, small, at the end of a short neck, with a faint lip. Length, 0.36 mm.; diameter, 0.27 mm.

Rare. Castle Hayne formation, at Natural Well.

Due to the preservation of the tests the internal structure is not visible but entosolenial tubes are visible in broken specimens. Recrystallization causes the tests of some specimens to be granular in appearance. Neck widths in the specimens vary and the apertural lips vary from narrow to broad and flaring. The Castle Hayne specimens differ from the type figure in the presence of a distinct lip, broader neck, and smaller size. The species was first reported from the Paleocene of Mississippi.

Plesiotype.—U.N.C. Cat. No. 3431.

Genus **DENTALINA** d'Orbigny, 1826

Dentalina budensis Hantken Pl. 24, fig. 6

Dentalina budensis Hantken, 1875, K. Ungar. Geol. Anst., Mitt. Jahrb., Budapest, Ungarn, Bd. 4, Heft 1, p. 34, pl. 3, fig. 12.

Test elongate, slightly curved, periphery lobulate, initial end bluntly rounded; chambers five in number, slightly inflated, closely appressed; sutures distinct, oblique, depressed; wall hyaline, finely perforate; aperture terminal, produced, round, radiate. Length, 0.62 mm.; width, 0.14 mm.

Rare. Castle Hayne formation, at Natural Well.

The Castle Hayne forms vary in length from 0.60 mm.—0.78 mm. in length and differ from the type figure in the smaller size, less produced aperture, and less strongly curved test.

Cushman (1935, U. S. Geol. Sur., Prof. Paper 181, p. 20) included *Dentalina budensis* Hantken, 1875, in synonymy with his new species, *D. hantkeni* Cushman (1933, Contr. Cushman Lab. Foram. Res., vol. 9, p. 9, pl. 1, figs. 18, 19). A comparison of the type figures indicates that the two species are different, and Cushman in placing *D. budensis* in synonymy with *D. hantkeni* did not follow the Zoological Rules of Nomenclature. A paratype of D. *hantkeni* Cushman designated by Cushman (1933, p. 9, pl. 1, fig. 18) is similar to *D. budensis* Hantken, and I believe it to be a synonym of *D. budensis*. A form identified later by Todd (1952, p. 12, pl. 2, fig. 7) is *D. budensis* and not *D. hantkeni* as she identified it. The type figure of *D. budensis* Hantken differs from the type figure of *D. hantkeni* Cushman in the more nearly transverse sutures, lower, more inflated chambers, and less curvilinear test. The type figure of *D. hantkeni* Cushman seems to be of an incomplete specimen which does not show the terminal chambers.

Plesiotype.—U.N.C. Cat. No. 3403.

Dentalina jacksonensis (Cushman and Applin) Pl. 24, fig. 7

Nodosaria jacksonensis Cushman and Applin, 1926, Am. Assoc. Pet. Geol., Bull., vol. 10, p. 170, pl. 7, figs. 14-16.

Dentalina jacksonensis Cushman, 1935, U. S. Geol. Sur., Prof. Paper 181, p. 20, pl. 8, figs. 7-9; Bergquist, 1942, Mississippi Geol. Sur., Bull. 49 (Fossils), p. 43, pl. 5, fig. 13; Cushman and Herrick, 1945, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 3, p. 58, pl. 9, fig. 15; Cushman, 1946, Cushman Lab. Foram. Res., Spec. Pub. 16, p. 13, pl. 3, fig. 9; Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 53, pl. 7, figs. 7a, 7b.

Test elongate, tapering, slightly curved, initial end ornamented with a short spine, usually not preserved in the Castle Hayne specimens, periphery lobulate; chambers globular, seven in number, loosely appressed; sutures depressed, distinct, composed of clear shell material; wall hyaline, finely perforate; aperture terminal, round, at the end of a short cylindrical neck, with a distinct lip. Length 0.75 mm.; width 0.15 mm.

Rare. Castle Hayne formation, at Natural Well.

The specimens range from 0.54 mm.—0.91 mm. in length with from six—nine chambers. Not all of the specimens are ornamented with an apical spine.

Plesiotype.—U.N.C. Cat. No. 3404.

Genus **NODOSARIA** Lamarck, 1812

Nodosaria magnoliaensis, new species Pl. 24, figs. 8a-b

Test elongate, cylindrical, initial end with distinct blunt spine; chambers distinct, without ornamentation, slightly inflated, elongate, two compose the test; suture distinct, depressed; wall hyaline, finely perforate; aperture terminal, central, simple, round, at the end of a short, produced neck. Length, 0.61 mm.; width, 0.15 mm.

Rare. Castle Hayne formation, at Natural Well.

The chambers in all specimens are elongate, but in most the initial chamber is larger and more elongate than the last. One specimen was found with three chambers. The forms range from 0.61 mm.—0.90 mm. in length and are 0.15 mm.—0.21 mm. in width.

Nodosaria magnoliaensis differs from *N. bulba* Howe (1939, pl. 6, fig. 5) in the larger size, distinct spine, longer chambers, and aperture at the end of a short neck. *Nodosaria calomorpha* Reuss, (1886, K. Akad. Wiss. Wien, Math.-Naturw. cl., Denkschr. Bd. 25, Abt. 1, p. 129, pl. 1, figs. 15-19) and *N. oligostegia* Reuss, (1845, Die Versteinerungen der bohmischen Kreide formation. Stuttgart, Deuschland. Abth. 1, p. 27, pl. 13, figs. 19-20) differ from *N. magnoliaensis* in their larger size and more inflated less elongate chambers. *Nodosaria calomorpha* may be a junior synonym of *N. oligostegia* because they are both similar.

Holotype.—U.N.C. Cat. No. 3425.

Genus **LAGENA** Walker and Boys, 1784

Lagena altahumerifera, new species Pl. 25, figs. 1a-b

Lagena acuticosta Cushman and Todd, 1945 (not Reuss), Contr. Cushman Lab. Foram. Res., vol. 21, pt. 4, p. 87, pl. 14, fig. 8.

Test pyriform, small, round in apertural view, broad at the base, tapering upward to a shoulder located high on the test, with a short neck; chamber ornamented with 11 prominent costae continuous from the base to the shoulder; aperture terminal, simple, round with a small lip. Length, 0.28 mm.; diameter, 0.19 mm.

Rare. Castle Hayne formation, at Natural Well.

Lagena altahumerifera resembles *L. humerifera* Bandy (1949, p. 56, pl. 7, fig. 17) but differs in the less prominent shoulder, lack of bifurcating costae, and the costae do not extend up to the neck. *Lagena isabella conscripta* Cushman and Barksdale (1930, Stanford Univ., Dept. Geology, Contr., vol. 1, p. 66, pl. 12, fig. 4) differs from *L. altahumerifera* in the more numerous and intercalated discontinuous costae.

Holotype.—U.N.C. Cat. No. 3414.

Lagena fenestrissima Howe and Ellis Pl. 25, figs. 2a-b

Lagena fenestrissima Howe and Ellis in Howe, 1939, Louisiana Dept. Cons., Geol. Bull. 14, p. 50, pl. 6, fig. 18.

Test large, globular; chamber ornamented with closely spaced hexagonal pits; aperture terminal, simple, round, on the end of a short, thin neck which is encircled by three nonspiralling collars. Length, 0.41 mm.; width, 0.30 mm.

Abundant. Castle Hayne formation, at Natural Well.

The species occurs throughout the formation and ranges from 0.36 mm.—0.41 mm. in length. There is considerable variation in the lengths of the necks, which vary from short to relatively long. The forms with long necks occur most abundantly and those with short necks appear to have been damaged. The collars encircling the neck vary from three—six. Weathered specimens lack collars.

Plesiotype.—U.N.C. Cat. No. 3415.

Lagena laevis (Montagu) Pl. 25, figs. 3a-b

Serpula (Lagena) laevis ovalis Walker and Boys, 1784, Minute Shells, p. 3, pl. 1, fig. 9.

Vermiculum laeve Montagu, 1803, Testacea Britannica, p. 524.

Lagena laevis Cushman, 1935, U. S. Geol. Sur., Prof. Paper 181, p. 22, pl. 9, figs. 3, 4; Howe, 1939, Louisiana Dept. Cons., Geol. Bull. 14, p. 50, pl. 6, fig. 12; Toulmin, 1941, Jour. Paleont., vol. 15, p. 593, pl. 80, fig. 7; Bergquist, 1942, Mississippi Geol. Sur., Bull. 49 (Fossils), p. 51, pl. 5, figs. 7, 8.

Test pyriform, round in apertural view, with a short neck; chamber smooth without ornamentation; aperture terminal, simple, round, with a definite lip. Length, 0.35 mm.; diameter, 0.21 mm.

Common. Castle Hayne formation, at Natural Well.

The character of the neck varies considerably in the Castle Hayne specimens. The neck is constricted immediately below the lip in some specimens and not in others. Some of the specimens have short, broad, tapering necks and in other specimens the neck is long and thin. The specimens range from 0.33 mm.—0.42 mm. in length.

Judging by the synonomy, Walker and Boys would seem to be the author of *Lagena laevis,* but they can only be credited with the naming of *L. ovalis.* The nature of the names *Serpula* (*Lagena*) *laevis ovalis* Walker and Boys 1784, seems to be descriptive names not in keeping with binomial nomenclature. This use of descriptive names is further illustrated by *Serpula tenuis ovalis laevis* Walker and Boys (1784, Testacea minuta rariora, p. 2, pl. 1, fig. 5), a name not in keeping with the system of binomial nomenclature. Montagu (1803, Testacea Brittanica, p. 524) named *Serpula laevis* in keeping with the binomial system of names and so is credited with the naming of the species. *Serpula* (*Lagena*) *laevis ovalis* Walker and Boys 1784 has since been put in synonomy with *Lagena laevis* (Montagu). [Not *Serpula L.,* 1758, Verm.]

Plesiotype.—U.N.C. Cat. No. 3416.

Lagena multicostata, new species Pl. 25, figs. 4a-b

Test subspherical, round in apertural view, with a short, stout, slightly tapering neck which is ornamented with six prominent, horizontal, annulations; surface of the chamber ornamented with about 50 fine, low, rounded costae of varying lengths, most of which extend from the base of the test to the base of the neck; aperture terminal, simple, round. Length, 0.36 mm.; diameter, 0.24 mm.

Rare. Castle Hayne formation, at Natural Well.

The specimens vary from 0.30 mm.—0.36 mm. in length and from 0.22 mm.—0.27 mm. in diameter. The neck annulations vary from four—six depending upon the length of the neck and the costae vary from 40-50.

Lagena multicostata differs from *L. striata* (d'Orbigny) (1839, Voyage dans l'Amérique méridionale, vol. 5, pt. 5, Foraminifères, p. 21, pl. 5, fig. 12) in the larger size, more spherical shape of the test, more numerous costae, broader neck, and neck annulations.

Holotype.—U.N.C. Cat. No. 3417.

Lagena ouachitaensis Howe and Wallace Pl. 25, fig. 5

Lagena ouachitaensis Howe and Wallace, 1932, Louisiana Dept. Cons., Geol. Bull. 2, p. 29, pl. 6, fig. 9; Bergquist, 1942, Mississippi Geol. Sur., Bull. 49 (Fossils), p. 51, pl. 5, fig. 29; Cushman, 1946, Contr. Cushman Lab. Foram. Res., Spec. Pub. 16, p. 15, pl. 4, fig. 9.

Test pyriform, elongate, round in apertural view with a short tapering neck, base broadly rounded with projecting costae; surface ornamented with nine irregularly spaced, prominent platelike costae, five continuing to near the top of the neck which is ornamented with three fine annulations; wall hyaline; aperture terminal, simple, round, with a distinct lip formed by the uppermost annulation. Length, 0.34 mm.; diameter, 0.15 mm.

Rare. Castle Hayne formation, at Natural Well.

Castle Hayne specimens are similar to the type figure in size and appearance but differ in having two or three less costae.

Plesiotype.—U.N.C. Cat. No. 3418.

Lagena sulcata laevicostata Cushman and Gray Pl. 25, figs. 6a-b

Lagena sulcata laevicostata Cushman and Gray, 1946, Contr. Cushman Lab. Foram. Res., vol. 22, p. 68, pl. 12, figs. 13-14.

Test subglobose, round in apertural view, with thick elongate tapering neck; surface ornamented with 19 prominent platelike costae, six continuing to the top of the neck in a slightly twisted manner, giving it a flanged appearance; aperture terminal, simple, round, small. Length, 0.48 mm.; diameter, 0.28 mm.

Rare. Castle Hayne formation, at Natural Well.

Costae of shorter lengths occur singly or in pairs between the six costae which continue to the top of the neck. The short costae terminate at the base of the neck or slightly below it. The costae on the neck vary somewhat in thickness.

Plesiotype.—U.N.C. Cat. No. 3419.

Lagena sulcata spirata Bandy Pl. 25, figs. 7a-b

Lagena sulcata Brady (part), 1884, *Challenger* Rept., Zoology, vol. 9, p. 462, pl. 57, fig. 23; Cushman, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 57, pl. 11, fig. 1.

Lagena sulcata spirata Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 57, pl. 7, fig. 18.

Test subglobose, main body of the chamber longer than wide, neck stout, slightly tapering; surface ornamented with about 36 prominent costae varying slightly in length, some extending from the base of the test to the base of the neck which is ornamented with a medium steep, spiral flange; aperture terminal, simple, round. Length, 0.48 mm.; diameter, 0.27 mm.

Rare. Castle Hayne formation at Natural Well.

The two specimens found differ from the type figure in the following respects; 12 more costae, less spherical shape of the chamber, and a less steeply angled neck flange.

Lagena multicostata (p. 245) differs from the species of *L. sulcata spirata* Bandy found at Natural Well in the more numerous, fine, low costae, smaller size, and horizontal annulations about the neck.

Plesiotype.—U.N.C. Cat. No. 3420.

Lagena torsicostata, new species Pl. 26, figs. 1a-b

Test large, subglobular, round in apertural view, with an elongate tapering neck; surface ornamented with 20 prominent, twisted, round-edged costae of varying lengths, not all of which extend to the base, about six continue to the top of the neck giving it a twisted ribbed appearance; aperture terminal, simple, round. Length, 0.40 mm.; diameter, 0.25 mm.

Common. Castle Hayne formation, at Natural Well.

Lagena torsicostata occurs throughout the formation and ranges from 0.39 mm.—0.45 mm. in length. The costae vary in number from 12-24, with 20 being most common. In a few specimens the costae are of lighter weight than those of the holotype.

Lagena tortilis Egger (1895, K. bayer. Akad. Wiss., math-physik. Cl. bd. 18, abth. 2, p. 329, pl. 10, figs. 61-63) differs from *L. torsicostata* in the smaller size, and fewer less prominent costae, all of which extend to the base.

Holotype.—U.N.C. Cat. No. 3421.

Lagena wallacei Bandy Pl. 26, figs. 2a-b

Lagena sp. (B) Howe and Wallace, 1932, Louisiana Dept. Cons., Geol. Bull. 2, p. 30, pl. 6, fig. 10; Bergquist, 1942, Mississippi Geol. Sur., Bull. 49 (Fossils), p. 53, pl. 5, fig. 26.

Lagena wallacei Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 57, pl. 7, fig. 19.

Test oval, elongate, round in apertural view with a short, tapering, narrow neck; surface ornamented with about 36 fine, narrow, low, costae; neck ornamented with four fine, slightly oblique, raised annulations; aperture terminal, simple, small, round. Length, 0.39 mm.; diameter, 0.17 mm.

Rare. Castle Hayne formation, at Natural Well.

The Castle Hayne specimen differs slightly from the type figure in the two less annulations and the annulations are slightly oblique.

Plesiotype.—U.N.C. Cat. No. 3422.

Genus **ROBULUS** Montfort, 1808

Robulus americanus (Cushman) Pl. 35, figs. 3a-b

Cristellaria americana Cushman, 1918, U. S. Geol. Survey, Bull. 676, p. 50, pl. 10, figs. 5, 6.

Robulus americanus Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 24, pl. 3, fig. 7; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 12, pl. 3, fig. 6; Renz, 1948, Geol. Soc. America, Mem. 32, p. 157, pl. 12, fig. 3.

Test circular, biconvex, umbonal areas raised, periphery subacute, smooth, with a narrow keel; chambers flattened, eight in outer whorl; sutures distinct, limbate, raised; wall calcareous, finely perforate, opaque; aperture a large triangular opening at the top of the apertural face. Diameter, 1.02 mm.; thickness, 0.51 mm.

Rare. Duplin marl, at Natural Well only.

This specimen has been damaged and severely weathered which probably accounts for its opaque appearance, but it seems to be identical with the type figure.

Plesiotype.—U.N.C. Cat. No. 3486.

Robulus deformis (Reuss) Plate 26, figs. 3a-b

Robulina deformis Reuss, 1851, Deutsche geol. Gesell. Zeitschr., Bd. 3, p. 70, pl. 4, figs. 30a, 30b.

Test subcircular in outline, thick, periphery acute with a distinct keel, smooth; chambers few, three in the last whorl, the first chamber in the last whorl subspherical in shape, later chambers increasing rapidly in height as added; sutures indistinct, strongly curved, flush with the surface; wall finely perforate, smooth, white, glossy; aperture slightly produced, an elongate slit at the top of the apertural face, radiate on the upper surface, apertural face is concave with angled margins. Diameter, 0.48 mm., thickness, 0.30 mm.

Rare. Castle Hayne formation, at Natural Well.

The specimens differ from the type figure in the less distinct sutures, smaller size, and subcircular outline but otherwise are strikingly similar enough to be included in the species.

Plesiotype.—U.N.C. Cat. No. 3439.

Robulus ovalis (Reuss) Pl. 26, figs. 4a-b

Cristellaria ovalis Reuss, 1844, Die Kreidegebilde des westlichen Böhmens, ein monographischer Versuch, vol. 2, p. 213; Reuss, 1845, Die Versteinerungen der bohmischen Kreideformation, pt. 1, pl. 8, fig. 49; pl. 12, fig. 19; pl. 13, figs. 60-63.

Test bulbous, tripyramidal, with two surfaces flat or slightly convex and one surface set back from keel-like flanges; chambers two in number, proloculus large, spherical, smooth, second chamber tripyramidal with three acute edges forming keel-like structures which extend halfway over the proloculus; wall hyaline, finely perforate; aperture terminal, a narrow slit at the top of the apertural face, radiate. Height, 0.42 mm.; width 0.30 mm.; thickness, 0.30 mm.

Rare. Castle Hayne formation, at Natural Well.

The adult form described by Reuss consists of five—six chambers, but the young stage which is composed of only two chambers is similar to the Castle Hayne specimens (Reuss, 1845, pl. 13, figs. 63a, 63b). No specimens of *R. ovalis* were found in the fauna with more than two chambers. Galloway and Morrey (1929, Bull. Amer. Paleont., vol. 15, No. 55, p. 21, pl. 2, figs. 11a, 11b) reported a similar form as *Robulus* cf. *deformis* (Reuss) from the upper Eocene of Ecuador. *Robulus ovalis* occurs in the Castle Hayne formation at Natural Well with *R. deformis* (Reuss) and is possibly a megaspheric example of *R. deformis.*

The species is placed in the genus *Robulus* because of the character of the apertural face and slitlike radial aperture in spite of the lack of an early coiled portion.

Plesiotype.—U.N.C. Cat. No. 3440.

Genus **FISSURINA** Reuss, 1850

Fissurina howei (Cushman and Todd) Pl. 26, figs. 5a-c

Entosolenia orbignyana (Seguenza) var. *elliptica* (Cushman) in Howe, 1939, Louisiana Dept. Cons., Geol. Bull. 14, p. 64, pl. 9, fig. 14.

Entosolenia howei Cushman and Todd, 1945, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 4, p. 95, pl. 15, fig. 29.

Test elongate, pyriform, small, oval in apertural view, with a narrow peripheral keel; wall smooth, finely perforate with a broad, downward curving lip around the aperture; aperture terminal, small, an elongate slit. Length, 0.32 mm.; width, 0.24 mm.; thickness. 0.16 mm.

Rare. Castle Hayne formation, at Natural Well.

The Castle Hayne forms are poorly preserved, and the downward curving lip is not visible in all the specimens, but this may be due to recrystallization. The type description is not clear as to whether the lip is a separate structure from the keel or is a part of the keel. In the Castle Hayne specimens the lip around the aperture is formed as a result of broadening of the keel.

Plesiotype.—U.N.C. Cat. No. 3407.

Fissurina orbignyana lacunata (Burrows and Holland) Pl. 35, figs. 4a-b

Lagena castrensis Brady, 1884 (not Schwager), *Challenger* Rept., Zoology, vol. 9, p. 485, pl. 60, figs. 1, 2; Balkwill and Wright, 1885, Trans. Roy. Irish Acad., vol. 28 (Sci.), p. 341, pl. 12, figs. 20, 21.

Lagena lacunata Burrows and Holland in Jones, 1895, Foram. Crag, p. 205, pl. 7, figs. 12a, 12b.

Lagena orbignyana var. *castrensis* Millet, 1901, Jour. Roy. Micr. Soc., p. 626, pl. 14, fig. 20.

Lagena orbignyana var. *lacunata* Sidebottom, 1910, Mem. Manchester Lit. Philos. Soc., vol. 54, No. 16, p. 19, pl. 2, fig. 14; Cushman, 1913, U. S. Nat. Mus., Bull. 71, pt. 3, p. 43, pl. 20, fig. 1; Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 32, pl. 5, figs. 13a, 13b; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 16, pl. 5, figs. 12a, 12b.

Fissurina orbignyana lacunata Puri, 1953, Florida Geol. Sur., Bull. 36, p. 115, pl. 26, figs. 2, 3.

Test oval, minute, inflated, with three peripheral keels and outer flanking raised rims on each side of the primary keels, chamber surface ornamented with small ovate pits; wall hyaline, finely perforate; aperture terminal, oval in shape, with an entosolenial tube extending down into the test. Length, 0.24 mm.; width, 0.21 mm.; thickness, 0.13 mm.

Rare. Duplin marl, at Natural Well and Barwick farm.

The type figure illustrates in side view a form with three primary keels and two flanking rims, but in apertural view only the three primary keels are illustrated. Unless the form is oriented properly in apertural view the two rims are easily missed.

Plesiotype.—U.N.C. Cat. No. 3470.

Family **POLYMORPHINIDAE** d'Orbigny, 1846

Genus **POLYMORPHINA** d'Orbigny, 1826

Polymorphina nuda Howe and Roberts Pl. 27, figs. 1a-b

Polymorphina advena nuda Howe and Roberts in Howe, 1939, Louisiana Dept. Cons., Geol. Bull. 14, p. 56, pl. 7, fig. 4; Cushman, 1946, Cushman Lab. Foram. Res., Spec. Pub. 16, p. 20, pl. 4, fig. 19.

Polymorphina nuda Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 65, pl. 9, figs. 8a, 8b.

Test elongate, compressed, sides flat, tapering at both ends, greatest width near the middle, periphery rounded; chambers biserial, increasing rapidly in size, six pairs compose the test; sutures nearly straight, flush with the surface; wall hyaline, smooth, finely perforate; aperture terminal, produced, radiate. Length, 0.40 mm.; width, 0.20 mm.; thickness, 0.06 mm.

Rare. Castle Hayne formation, at Natural Well.

The specimens range from 0.40 mm.—0.57 mm. in length and in a few specimens the initial end is pointed. The other characters remain constant. The type figure differs from these specimens in the smaller size and fewer chambers. The species is atypical for the genus in that *Polymorphina* typically has a twisted biserial chamber arrangement, whereas *P. nuda* has a straight biserial chamber arrangement.

Plesiotype.—U.N.C. Cat. No. 3434.

Genus **PSEUDOPOLYMORPHINA** Cushman and Ozawa, 1928

Pseudopolymorphina rutila (Cushman) Pl. 35, figs. 5a-b

Polymorphina regina Brady, Parker, and Jones, var. *rutila* Cushman, 1923, U. S. Geol. Sur., Prof. Paper 133, p. 34, pl. 5, figs. 7, 8.

Pseudopolymorphina rutila Cushman and Ozawa, 1930, U. S. Nat. Mus., Proc., vol. 77, art. 6, p. 100, pl. 26, figs. 3a, 3b; Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 36, pl. 5, fig. 20; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 19, pl. 6, fig. 11; Puri, 1953, Florida Geol. Sur., Bull. 36, p. 105, pl. 21, fig. 8; McLean, 1956, Bull. Amer. Paleont., vol. 36, No. 160, p. 335, pl. 41, figs. 6-9, 16, 17.

Test elongate, compressed, widest near the base tapering towards the aperture, with a prominent basal spine; chambers elongate, inflated, alternating, about seven in number, loosely appressed; sutures distinct, depressed; wall hyaline, finely perforate, ornamented with a few prominent discontinuous costae; aperture terminal, broken on this specimen, but probably round and radiate. Length, 1.26 mm.; width, 0.36 mm.; thickness, 0.33 mm.

Rare. Duplin marl, at Natural Well and Barwick farm.

The Duplin specimens differ from the type figure in being larger, less fusiform, with more elongate chambers whose proximal ends are closer to the proloculus. The figured specimen has one chamber nearly completely destroyed, thereby altering the apparent shape of the test. A second nonfigured specimen differs in having less inflated chambers and nearly parallel edges as seen in side view. McLean (1956, pl. 41) illustrated a considerable variation to the species.

Plesiotype.—U.N.C. Cat. No. 3482.

Genus **SIGMOMORPHINA** Cushman and Ozawa, 1928

Sigmomorphina pulchra Todd Pl. 27, figs. 2a-c

Sigmomorphina pulchra Todd, 1952, U. S. Geol. Sur., Prof. Paper 241, p. 20, pl. 3, fig. 13.

Test elongate, oval in apertural view, slightly compressed, greatest width near the middle, initial and apertural ends equally acute; chambers slightly inflated, sigmoid, each succeeding chamber added farther from the base, moderately appressed; sutures distinct, slightly depressed; wall hyaline, smooth, finely perforate; aperture terminal, round, radiate. Length, 0.45 mm.; width, 0.20 mm.; thickness, 0.15 mm.

Rare. Castle Hayne formation, at Natural Well.

The specimens from this locality are smaller but otherwise similar to the type figure.

Plesiotype.—U.N.C. Cat. No. 3441.

Sigmomorphina terquemiana (Fornasini) Pl. 36, figs. 1a-c

Polymorphina amygdaloides Terquem, 1878 (not Reuss, 1856), Soc. Géol. France, Mem., sér. 3, tome 1, No. 3, p. 39, pl. 3, fig. 25.

Polymorphina amygdaloides Reuss var. *terquemiana* Fornasini, 1900, Soc. Géol. Ital., Boll., vol. 19, p. 136.

Sigmomorphina semitecta terquemiana Cushman and Ozawa, 1930, U. S. Nat. Mus., Proc., vol. 77, art. 6, p. 129, pl. 34, figs. 2a-c.

Test fusiform, compressed, oval in apertural view, initial end subacute, greatest width near the middle of the test; chambers closely appressed, elongate, arranged in a sigmoid series, rapidly enlarging as added; sutures distinct, nearly vertical, slightly depressed; wall hyaline, finely perforate; aperture terminal, large, round, radiate. Length, 0.48 mm.; width, 0.24 mm.; thickness, 0.14 mm.

Rare. Duplin marl, at Natural Well only.

Terquem in 1878 (Soc. Géol. France, Mem., sér. 3, tome 1, No. 3, p. 39, pl. 3, figs. 22-30) described this species using a syntypic series which undoubtedly includes more than one species. To preserve the taxonomic value of the species this author designates the specimen, fig. 25 of Terquem, as the lectotype.

Plesiotype.—U.N.C. Cat. No. 3488.

Genus **LARYNGOSIGMA** Loeblich and Tappan, 1953

Laryngosigma williamsoni (Terquem) Pl. 35, fig. 6

Polymorphina lactea oblonga Williamson, 1858 (not *P. oblonga* Roemer, 1838, nor P. oblonga d'Orbigny, 1846), Rec. Foram. Gt. Britain, p. 71, pl. 6, figs. 149, 149a.

Polymorphina williamsoni Terquem, 1878, Soc. Géol. France, Mém., sér. 3, tome 1, No. 3, p. 37.

Sigmomorphina williamsoni Cushman and Ozawa, 1930, U. S. Nat. Mus., Proc., vol. 77, art. 6, p. 138, pl. 38, figs. 3, 4; Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 36, pl. 6, fig. 4; Puri, 1953, *ibid.*, Bull. 36, p. 110, pl. 28, fig. 7; McLean, 1956, Bull. Amer. Paleont., vol. 36, No. 160, p. 338, pl. 42, figs. 1-4.

Laryngosigma williamsoni (Terquem), Loeblich and Tappan, 1953, Smithsonian Inst., Misc. Coll., vol. 121, No. 7, p. 83.

Test small, oblong, oval in apertural view, edges broadly rounded; chambers few, distinct, elongate, added in a sigmoid series; sutures distinct, slightly depressed, nearly vertical; wall thin, hyaline, finely perforate; aperture terminal, radiate, with a short entosolenian tube extending into the test. Length, 0.40 mm.; width, 0.19 mm.

Rare. Duplin marl, at Natural Well.

Two specimens were found and both disintegrated during the photographing process. The tests were extremely fragile. The Duplin specimens differed from the type figure in the thicker test, smaller size, fewer chambers, and pointed basal end. The apertural characters were not noted in detail before disintegration of the tests. The specimens found possibly were young forms.

Genus **GUTTULINA** d'Orbigny, 1839

Guttulina sp. Pl. 27, figs. 3a-c

Test elongate, acute at the initial and apertural end, greatest width near the middle, compressed, oval in apertural view; chambers few, slightly inflated, added alternately, each succeeding one farther from the base; sutures distinct, slightly depressed; wall hyaline, finely perforate; aperture terminal, large, round, radiate. Length, 0.57 mm.; width, 0.30 mm.; thickness, 0.19 mm.

Rare. Castle Hayne formation, at Natural Well.

The single specimen found cannot be satisfactorily identified with any previously described species. *Guttulina caudata* d'Orbigny as figured by Cushman and Ponton (1932, p. 65, pl. 9, fig. 17) is somewhat similar but differs from the Castle Hayne form in the more numerous chambers and distinct spine on the initial chamber. *Guttulina stavensis* Bandy (1949, p. 69, pl. 10, fig. 3a-c) differs in the more numerous chambers, lobulate periphery, and the chambers are added farther from the base.

Plesiotype.—U.N.C. Cat. No. 3413.

Guttulina communis (d'Orbigny) Pl. 27, figs. 4a-c

Polymorphina (Guttulina) communis d'Orbigny, 1826, Ann. Sci. Nat., ser. 1, vol. 7, p. 266, pl. 12, figs. 1-4; d'Orbigny, 1846, Foraminifères fossiles du bassin tertiaire de Vienne, p. 224-225.
Guttulina irregularis Cushman (not d'Orbigny), 1935, U. S. Geol. Sur., Prof. Paper 181, p. 24, pl. 9, figs. 13-16.
Guttulina communis Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 68, pl. 9, figs. 12a, 12b.

Test small, slightly wider than long, equilaterally triangular in side view, triangular in apertural view, edges round; chambers few, inflated, elongate, each extending to the base; sutures distinct, slightly depressed; wall hyaline, smooth, finely perforate; aperture terminal, oval, radiate. Length, 0.30 mm.; width, 0.31 mm.; thickness, 0.19 mm.

Common. Castle Hayne formation, at Natural Well.

This species occurs throughout the formation with only slight variation. Most specimens are more elongate than the holotype or the figured Castle Hayne specimen.

Bandy (1949, p. 68) included in his synonymy several specimens identified incorrectly by Cushman and Bergquist as *G. irregularis* d'Orbigny.

Plesiotype.—U.N.C. Cat. No. 3412.

Guttulina costatula Galloway and Wissler Pl. 36, figs. 2a-b

Polymorphina (Guttulina) costatula Galloway and Wissler, 1927, Jour. Paleont., vol. 1, p. 57, pl. 9, figs. 10a, 10b.

Guttulina costatula Cushman and Ozawa, 1930, U. S. Nat. Mus., Proc., vol. 77, art. 6, p. 35, pl. 6, figs. 3a, 3b; Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 33, pl. 5, fig. 15; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 17, pl. 6, figs. 1a, 1b; Puri, 1953, Florida Geol. Sur., Bull. 36, p. 106, pl. 21, fig. 7.

Test fusiform, short, acute at both ends, with a short blunt prolocular spine, suboval in apertural view; chambers five in number, arranged in a counterclockwise polymorphine spiral, each one removed farther from the base, ornamented with about 30 fine costae some of which are continuous from one chamber to the next; wall hyaline, finely perforate; aperture terminal, medium large, produced, round, radiate. Length, 0.46 mm.; width, 0.27 mm.

Rare. Duplin marl, at Natural Well only.

The type figure and type description of this form are incongruous. The type description speaks of 12-15 low rounded costae and the type figure illustrates about 12 costae per chamber, or a total of 32 costae, in apertural view. The Duplin marl specimen seems to have about 30 costae and is identified as *Guttulina costatula* Galloway and Wissler on the basis of the type figure.

Plesiotype.—U.N.C. Cat. No. 3476.

Genus **RAPHANULINA** Zborzewski, 1834

Raphanulina gibba (d'Orbigny) Pl. 28, figs. 1a-c

Polymorphina (Globuline) gibba d'Orbigny, 1826, Ann. Sci. Nat., ser. 1, vol. 7, p. 266, Modele No. 63.

Globulina gibba Cushman, 1935, U. S. Geol. Sur., Prof. Paper 181, p. 25, pl. 9, fig. 18; Bergquist, 1942, Mississippi Geol. Sur., Bull. 49 (Fossils), p. 55, pl. 6, fig. 8; Cushman and Todd, 1945, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 4, p. 88, pl. 14, fig. 13; Cushman, 1946, Cushman Lab Foram. Res., Spec. Pub. 16, p. 18, pl. 4, fig. 16; Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 70, pl. 10, figs. 4a, 4b.

Test globular, subcircular in apertural view; chambers few, inflated, three in the last whorl; sutures flush with the surface, oblique; wall smooth, finely perforate; aperture, terminal, round, radiate. Length, 0.33 mm.; width, 0.27 mm.; thickness, 0.21 mm.

Rare. Castle Hayne formation, at Natural Well.

The Castle Hayne specimens differ from the type figure and from those identified by later workers in the subcircular rather than spherical shape of the test. The suture lines of the test illustrated in the type figure are strongly curved and the suture lines of Castle Hayne specimens are only slightly curved; however, these specimens seem identical with forms identified by later workers except for the subcircular shape of the test.

Raphanulina amplectens (Reuss) (1851, Deutsche geol. Gesell. Zeitscher. Bd. 3, p. 81, pl. 6, fig. 44) is similar to the Castle Hayne species but differs in the larger size, less closely appressed chambers, and the suture lines do not extend as high on the test.

Plesiotype.—U.N.C. Cat. No. 3437.

Raphanulina sp. cf. **R. hispida** (Terquem) Pl. 36, figs. 3a-c

Globulina hispida Terquem, 1882, Soc. Géol. France, Mém., sér. 3, tome 2, p. 131, pl. 13, fig. 32.

Test slightly compressed, edges broadly rounded, lateral chamber subangular, suboval in apertural view; chambers closely appressed, four in the last whorl, slightly inflated; sutures distinct, slightly depressed; wall hyaline, finely perforate, hispid; aperture terminal, oval in shape, radiate. Length, 0.36 mm.; width, 0.23 mm.; thickness, 0.18 mm.

Rare. Duplin marl, at Natural Well only.

The Duplin marl specimen differs from the type figure in the thicker test, more numerous chambers (four instead of three), less produced aperture and different sutural pattern. *Raphanulina inaequalis caribaea* (d'Orbigny) (1839, Foraminifères, in de la Sagra, Histoire, physique, politique et naturelle de l'ile de Cuba, p. 135, pl. 2, figs. 7, 8) is similar to the Duplin marl species but differs in the smaller size, fewer, more inflated chambers, regular shape, and different sutural pattern.

Plesiotype.—U.N.C. Cat. No. 3484.

Raphanulina sp. cf. **R. laeviglobosa** ten Dam Pl. 36, figs. 4a-c

Globulina laeviglobosa ten Dam, 1944, Netherlands, Geol. Stichting, Meded., ser. C, vol. 5, No. 3, p. 107, pl. 1, figs. 1a-c.

Test globular, wider than long, edges rounded, oval in apertural view; chambers greatly inflated, distinct, four in the last whorl, added alternately, each succeeding chamber extending nearly to the base; sutures distinct, depressed; wall hyaline, smooth, finely perforate; aperture terminal, large, round, radiate. Length, 0.52 mm.; width, 0.57 mm.; thickness, 0.40 mm.

Rare. Duplin marl, at Natural Well only.

The single Duplin marl specimen differs from the type figure in the more broadly rounded chambers, deeply depressed sutures, and greater number of chambers.

Plesiotype.—U.N.C. Cat. No. 3485.

Raphanulina subglobosa, new species Pl. 28, figs. 2a-c

Test oval, slightly compressed; chambers few, three in the last whorl, closely appressed, distinct, added alternately, inflated; sutures distinct, slightly depressed; wall smooth, finely perforate; aperture terminal, large, round, radiate. Length, 0.50 mm.; width, 0.35 mm.; thickness, 0.30 mm.

Rare. Castle Hayne formation, at Natural Well.

The specimens range from 0.30 mm.—0.50 mm. in length, from 0.21 mm.—0.35 mm. in width, and from 0.16 mm.—0.30 mm. in thickness. In addition to size variations the specimens have from three-four chambers and a few are slightly more compressed than the holotype.

Raphanulina subglobosa may be distinguished from *R. inaequalis* (Reuss) (1850, Denkschr. K. Akad. Wiss. Wien, vol. 1, p. 377, pl. 48, fig. 9) by the smaller size, thicker, less symmetrical test, and the aperture is not attenuated as it is in *R. inaequalis*. Cushman and Cahill described a similar form as *R. inaequalis* (1933, p. 18, pl. 6, figs. 7, 8), but it differs from the Castle Hayne species in having the second chamber extend higher up on the test. A variation has been described as *R. inaequalis* (Reuss) (see Cushman and Cahill, 1933, p. 18 for a complete synonomy) and most all are different from the type figure of *R. inaequalis*.

Holotype.—U.N.C. Cat. No. 3438.

Genus **RAMULINA** Jones, 1875

Ramulina globulifera Brady Pl. 28, fig. 3

Ramulina globulifera Brady, 1879, Quart. Jour. Micr. Sci., vol. 19, p. 272, pl. 8, figs. 32, 33; Bergquist, 1942, Mississippi Geol. Sur., Bull. 49 (Fossils), p. 59, pl. 6, fig. 21; Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Pub. 25, p. 164, pl. 11, figs. 10, 11.

Test consists of a large globular central chamber from which extend six thin cylindrical tubes of varying lengths; wall hyaline, finely perforate, ornamented with short distinct spines; apertures apparently at the end of the cylindrical tubes. Length, 0.75 mm.; tube diameter, 0.08 mm.

Rare. Castle Hayne formation, at Natural Well.

The Natural Well specimens are all apparently fragmental portions of a once larger branching network. The specimens vary from 0.57 mm.—0.75 mm. in length and one specimen was found with two spheres.

Plesiotype.—U.N.C. Cat. No. 3436.

Family **NONIONIDAE** Reuss, 1860

Genus **NONION** Montfort, 1803

Nonion danvillensis Howe and Wallace Pl. 28, figs. 4a-b

Nonion danvillensis Howe and Wallace, 1932, Louisiana Dept. Cons., Geol. Bull. 2, p. 51, pl. 9, figs. 3a, 3b.
Nonion danvillense Cushman, 1939, U. S. Geol. Sur., Prof. Paper 191, p. 5, pl. 1, fig. 19.
Nonion danvillensis Bergquist, 1942, Mississippi Geol. Sur., Bull. 49 (Fossils), p. 60, pl. 6, fig. 25.
Nonion danvillense Cushman and Todd, 1945, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 4, p. 92, pl. 15, fig. 4.
Nonion danvillensis Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 72, pl. 10, figs. 10a, 10b.

Test higher than wide, compressed, periphery broadly rounded. lobulate, umbilici depressed, papillate; chambers inflated, rapidly enlarging, closely appressed in the early portion, becoming more loosely appressed in the later portion, six in the final volution; sutures distinct, radial, strongly depressed; wall hyaline, finely perforate; aperture a high broad arch at the base of the apertural face. bordered by a distinct lip. Diameter, 0.30 mm.; thickness, 0.18 mm.

Abundant. Castle Hayne formation, at Natural Well.

This species occurs abundantly throughout the formation with only slight variation except for size. The forms range from 0.24 mm.—0.30 mm. in diameter. The type figures of *N. danvillensis* Howe and Wallace and *N. micrus* Cole (1927, Bull. Amer. Paleont., vol. 14, No. 51, p. 22) are similar, but Cole's original description and figure do not mention nor illustrate an umbilical filling nor aperture bordered by a definite lip. The Castle Hayne specimens are placed in *N. danvillensis* Howe and Wallace. Cole's original figure does not include an apertural view.

Plesiotype.—U.N.C. Cat. No. 3426.

Nonion decoratus Cushman and McGlamery Pl. 37, figs. 1a-b

Nonion advenum Cushman and McGlamery, 1938, (part) (not Cushman), U. S. Geol. Sur., Prof. Paper 189-D, p. 106, pl. 24, figs. 23a, 23b, not fig. 22.

Nonion decoratum Cushman and McGlamery, 1939, Contr. Cushman Lab. Foram. Res., vol. 15, p. 46, pl. 9, figs. 4a, 4b; Cushman and McGlamery, 1942, U. S. Geol. Sur., Prof. Paper 197-B, p. 69, pl. 5, fig. 9; Todd, 1952, *ibid.*, Prof. Paper 241, p. 21, pl. 3, figs. 19a, 19b.

Test subcircular in outline, small, sides nearly parallel in apertural view, periphery broadly rounded, lobulate in the later portion of the test, umbilical areas filled with beaded masses of clear shell material surrounding a prominent central boss; chambers slightly inflated, nine in the outer whorl; sutures curved, radial, ornamented with fine granules of shell material near the umbilicus, flush with the surface in the early portion, later sutures becoming depressed; wall hyaline, finely perforate; aperture a low arch at the base of the apertural face. Diameter, 0.30 mm.; thickness, 0.14 mm.

Rare. Duplin marl, at Natural Well and Barwick farm.

The Duplin marl specimens have from 8-10 chambers and range from 0.25 mm.—0.36 mm. in size, differing from the type figure in the less prominent central boss, less lobulate periphery, more curved suture lines, and nonlimbate sutures.

Plesiotype.—U.N.C. Cat. No. 3478.

Nonion mauricensis Howe and Ellis Pl. 29, figs. 1a-b

Nonion mauricensis Howe and Ellis in Howe, 1939, Louisiana Dept. Cons., Geol. Bull. 14, p. 57, pl. 8, figs. 1, 2; Cushman and Todd, 1945, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 1, p. 15, pl. 3, figs. 27, 28; Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 73, pl. 10, figs. 12a, 12b.

Test small, higher than wide, sides parallel in edge view, umbilici flush with the surface, large, papillate, periphery rounded, lobulate; chambers closely appressed, enlarging rapidly, slightly inflated in the later portion of the test, eight in the last whorl; sutures distinct, radial, slightly curved, depressed; wall hyaline, finely perforate; aperture a low arch at the base of the apertural face. Diameter, 0.33 mm.; thickness, 0.12 mm.

Common. Castle Hayne formation, at Natural Well.

This species occurs with slight variation throughout the formation, such as eight or nine chambers in the outer whorl, the size of the granular umbilical filling and the relative expansion of the terminal chamber. The Castle Hayne specimens differ from the type figure mainly in their larger size.

Plesiotype.—U.N.C. Cat. No. 3427.

Nonion planatus Cushman and Thomas Pl. 29, figs. 2a-b

Nonion planatum Cushman and Thomas, 1930, Jour. Paleont., vol. 4, p. 37, pl. 3, figs. 5a, 5b; Cushman and Dusenbury, 1934, Contr. Cushman Lab. Foram. Res., vol. 10, p. 60, pl. 8, figs. 6a, 6b; Cushman, 1939, U. S. Geol. Sur., Prof. Paper 191, p. 4, pl. 1, figs. 15a, 15b; Bergquist, 1942, Mississippi Geol. Sur., Bull. 49 (Fossils), p. 61, pl. 6, fig. 24; Cushman and Todd, 1945, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 1, p. 15, pl. 3, fig. 29; Cushman and Herrick, 1945, *ibid.*, pt. 3, p. 61, pl. 10, fig. 8; Cushman and Todd, 1945, *ibid.*, pt. 4, p. 92, pl. 15, fig. 2; Cushman, 1946, Cushman Lab. Foram. Res., Spec. Pub. 16, p. 21, pl. 4, fig. 24.

Nonion planatus Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 74, pl. 11, figs. 1a, 1b.

Test large, planispiral, close coiled, umbilici slightly depressed, periphery broadly rounded, smooth; chambers distinct, not inflated, increasing gradually in size, nine in the last volution; sutures distinct, flush in the early portion, slightly depressed in the later portion, radial, slightly curved, forming a thickened ring with slight inward projections in the umbilici; wall hyaline, medium perforate; aperture a low arch at the base of the apertural face. Diameter 0.42 mm.; thickness 0.18 mm.

Abundant. Castle Hayne formation, at Natural Well.

The specimens vary considerably in size from 0.24 mm.—0.42 mm. and have from nine-ten chambers; forms with nine chambers are more prevalent. The relative sizes of the umbilical areas vary from small to moderately large.

Plesiotype.—U.N.C. Cat. No. 3428.

Genus **NONIONELLA** Cushman, 1926

Nonionella jacksonensis Cushman Pl. 29, figs. 3a-c

Nonionella jacksonensis Cushman, 1933, Contr. Cushman Lab. Foram. Res., vol. 9, p. 10, pl. 1, figs. 23a-c; Cushman, 1935, U. S. Geol. Sur., Prof. Paper 181, p. 31, pl. 12, figs. 3, 4; Cushman, 1939, *ibid.*, Prof. Paper 191, p. 29, pl. 8, figs. 2a-c; Howe, 1939, Louisiana Dept. Cons., Geol. Bull. 14, p. 59, pl. 8, figs. 5-7; Bergquist, 1942, Mississippi Geol. Sur., Bull. 49 (Fossils), p. 62, pl. 6, fig. 23; Cushman and Todd, 1945, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 4, p. 93, pl. 15, fig. 8; Cushman, 1946, Cushman Lab. Foram. Res., Spec. Pub. 16, p. 22, pl. 4, fig. 26.

Test minute, higher than wide, periphery rounded, dorsal side slightly evolute, ventral side involute; chambers distinct, eight in the final whorl, increasing rapidly in size and elongation as added, last chamber highly inflated, extending across the umbilical area almost to the periphery on the ventral side; sutures distinct, curved, slightly depressed; wall hyaline, finely perforate; aperture peripheral, a low arch at the base of the apertural face. Height, 0.27 mm.; width, 0.20 mm.; thickness, 0.15 mm.

Common. Castle Hayne formation, at Natural Well.

The species occurs in the lower half of the exposed formation, and all the specimens are abnormally small but otherwise seem identical to the type figure. Cushman (1935, p. 31) reported specimens only slightly larger from the Ocala limestone of Alabama and the Cooper marl of South Carolina.

Plesiotype.—U.N.C. Cat. No. 3429.

Nonionella spissa Cushman Pl. 29, figs. 4a-c

Nonionella hantkeni spissa Cushman, 1931, Contr. Cushman Lab. Foram. Res., vol. 7, p. 58, pl. 7, figs. 13a-c; Cushman, 1939, U. S. Geol. Sur., Prof. Paper 191, p. 30, pl. 8, fig. 5; Cushman and Herrick, 1945, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 4, p. 63, pl. 10, fig. 12.

Nonionella spissa Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 78, pl. 11, figs. 2a-c, 4a-c.

Test higher than wide, subovate in outline, periphery rounded to slightly angled, not lobulate, dorsal side slightly evolute, ventral side involute, umbilical area on the ventral side coarsely granular, with granules extending slightly into adjacent sutures; chambers closely appressed, nine in the last whorl, increasing gradually in size as added, last chamber slightly inflated, extending only to the umbilicus; sutures distinct, radial, gently curved, flush with the surface in the early portion, becoming slightly depressed in the later portion; wall hyaline, finely perforate; aperture peripheral, a low arch at the base of the apertural face, extending slightly toward the ventral side. Diameter 0.39 mm.; thickness 0.15 mm.

Rare. Castle Hayne formation, at Natural Well.

The specimens vary from the type figure in the slightly smaller size and fewer chambers but are similar to those reported by Cushman and Herrick (1945, pl. 10, fig. 12) and by Bandy (1949, pl.

11, fig. 4a-c). The relative degree of expansion in the last few chambers is variable in the Castle Hayne specimens.

Plesiotype: U.N.C. Cat. No. 3430.

Genus **ELPHIDIUM** Montfort, 1808

Elphidium advena (Cushman) Pl. 37, figs. 2a-b

Polystomella subnodosa Brady, 1884 (not von Munster), *Challenger* Rept., Zoology, vol. 9, p. 734, pl. 110, figs. 1a, 1b.

Polystomella advena Cushman, 1922, Carnegie Inst. Washington, Pub. 311, p. 56, pl. 9, figs. 11, 12.

Elphidium advenum Cushman, 1930, U. S. Nat. Mus., Bull. 104, pt. 7. p. 25, pl. 10, figs. 1, 2; Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 40, pl. 7, figs. 7a, 7b; Cushman and Ponton, 1932, Florida Geol. Sur., Bull. 9, p. 70, pl. 11, figs. 1a, 1b; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 22, pl. 7, figs. 10a, 10b; Cushman, 1939, *ibid.*, Prof. Paper 191, p. 60, pl. 16, figs. 31-35; McLean, 1956, Bull. Amer. Paleont., vol. 36, No. 160, p. 341, pl. 43, figs. 5a, 5b.

Test higher than wide, compressed, periphery smooth, acute, with a narrow keel, umbilical regions slightly depressed, with secondary calcareous filling; chambers distinct, raised, later ones inflated, 10 visible; sutures depressed, radial, curved, with stout retral processes; wall finely perforate, glossy white in appearance; aperture composed of a few small round openings at the base of the apertural face. Diameter, 0.42 mm.; thickness, 0.18 mm.

Common. Duplin marl, at Natural Well and Barwick farm.

Duplin marl representatives range from 0.30 mm.—0.55 mm. in diameter, with from 8-12 chambers.

Plesiotype.—U.N.C. Cat. No. 3466.

Elphidium compressulum, new species Pl. 37, figs. 3a-b

Test higher than wide, thin, strongly compressed, periphery rounded, smooth in the early portion, becoming slightly lobulate in the later portion, umbilical areas depressed; chambers flattened in the early portion, becoming slightly inflated; 11 visible in the last whorl; sutures distinct, radial, flush with the surface in the immature portion, becoming slightly depressed in the later portion, with short, broad, retral processes visible on all sutures; wall hyaline, coarsely perforate; aperture composed of small rounded openings at the base of the apertural face and scattered about the apertural face. Diameter, 0.34 mm.; thickness, 0.12 mm.

Common at Natural Well, rare at Barwick farm. Duplin marl.

The specimens range from 0.26 mm.—0.34 mm. in diameter with from 9-11 chambers. *E. translucens* Natland (1938, Scripps Inst. Oceanography, Bull., vol. 4, p. 144, pl. 5, figs. 3, 4) differs in the larger size, more numerous chambers, subcircular outline, broader sutures, and thicker test.

Holotype.—U.N.C. Cat. No. 3467.

Elphidium gunteri Cole Pl. 37, figs. 4a-b

Elphidium gunteri Cole, 1931, Florida Geol Sur., Bull. 6, p. 34, pl. 4, figs. 9, 10.

Test subcircular in outline, periphery smooth, not lobulate, broadly rounded, umbilical regions filled with clear shell material; chambers distinct, not inflated, 11 visible in the last whorl; sutures distinct, flush with the surface, radial, slightly curved, with raised rectangular retral processes; wall hyaline, finely perforate; aperture composed of a series of small rounded openings at the base of the apertural face. Diameter, 0.41 mm.; thickness, 0.20 mm.

Rare. Duplin marl, at Natural Well and Barwick farm.

The specimens range from 0.30 mm.—0.47 mm. in diameter with 11-14 chambers. The Duplin marl forms differ slightly from the type figure in the finely perforate wall, reduced umbilical filling, and fewer chambers in some specimens.

Plesiotype.—U.N.C. Cat. No. 3468.

Elphidium limatulum, new species Pl. 37, figs. 5a-b

Test subcircular in outline, thick, periphery broadly rounded, slightly lobulate, umbilical areas depressed, filled with clear granular shell material; chambers flattened in the early portion becoming slightly inflated in the later portion of the test, nine visible in the last whorl; sutures distinct, depressed, with short, broad retral processes which are indistinct in the early portion of the test; wall white, glossy, finely perforate; aperture composed of small rounded openings at the base of the apertural face. Diameter, 0.42 mm.; thickness, 0.21 mm.

Common. Duplin marl, at Natural Well and Barwick farm.

This species ranges from 0.36 mm.—0.55 mm. in diameter with 8-11 chambers, 10 being the most common.

Elphidium limatulum resembles *E. poeyanum* (d'Orbigny) but differs in the less lobulate periphery, less distinct retral processes, and the more finely perforate test. *E. nautiloideum* Galloway and Heminway (1941, New York Acad. Sci., vol. 3, pt. 4, p. 362, pl. 14, figs. 5a, 5b) differs in the greater number of chambers, shorter apertural face, and distinct retral processes.

Holotype.—U.N.C. Cat. No. 3495.

Elphidium poeyanum (d'Orbigny) Pl. 37, figs. 6a-b

Polystomella poeyana d'Orbigny, 1839, Foraminifères, in de la Sagra, Histoire physique, politique et naturelle de l'ile de Cuba, p. 55, pl. 6, figs. 25, 26.

Elphidium poeyanum Cushman, 1929, U. S. Nat. Mus., Bull. 104, pt. 7, p. 25, pl. 10, figs. 4, 5; Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 39, pl. 7, figs. 3, 4; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 21, pl. 7, figs. 7a, 7b; Cushman, 1939, *ibid.*, Prof. Paper 191, p. 54, pl. 14, figs. 25, 26; Galloway and Heminway, 1941, New York Acad. Sci., vol. 3, pt. 4, p. 363, pl. 14, figs. 6a, 6b.

Test compressed, periphery slightly lobulate, broadly rounded, umbilical regions depressed; chambers in the later portion of the test inflated, 10 visible; sutures distinct, slightly depressed, with short broad retral processes; wall hyaline, coarsely perforate; aperture composed of a series of small rounded openings at the base of the apertural face. Diameter, 0.29 mm.; thickness, 0.12 mm.

Common. Duplin marl, at Natural Well and Barwick farm.

Duplin marl species range from 0.29 mm.—0.51 mm. in diameter, with 9-12 chambers.

Plesiotype.—U.N.C. Cat. No. 3469.

Family **ROTALIIDAE** Reuss, 1860

Genus **GLOBOROTALIA** Cushman, 1927

Globorotalia menardii (d'Orbigny) Pl. 38, figs. 1a-c

Rotalia menardii d'Orbigny, 1826, Ann. Sci. Nat., ser. 1, vol. 7, p. 273, model 10.

Pulvinulina menardii Brady, 1884, *Challenger* Rept., Zoology, vol. 9, p. 690, pl. 103, figs. 1, 2.

Pulvinulina tumida Brady, *ibid.*, p. 692, pl. 103, figs. 4-6.

Globorotalia menardii Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 60, pl. 12, figs. 1a-c; Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 91, pl. 17, fig. 1a-c; Cole and Ponton, 1932, Florida Geol. Sur., Bull. 5, p. 45, pl. 11, figs. 4, 5; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 34, pl. 12, fig 5a-c; Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Pub. 25, p. 286, pl. 22, figs. 9-11; Puri, 1953, Florida Geol. Sur., Bull. 36, p. 150, pl. 25, figs. 4-6.

Test plano-convex, small, trochoid, periphery subacute, slightly lobulate, with a definite keel; chambers flattened on the dorsal side, inflated on the ventral side, four in the adult whorl; sutures curved, radial, limbate, and raised on the dorsal side, depressed, nearly straight, radial on the ventral side; wall hyaline, medium perforate; aperture ventral, a narrow elongate slit bordered by a definite lip, between the umbilicus and the periphery at the base of the septal face. Diameter, 0.39 mm.; thickness, 0.20 mm.

Rare. Duplin marl, at Natural Well and Barwick farm.

Plesiotype.—U.N.C. Cat. No. 3475.

Globorotalia spinulosa Cushman Pl. 29, figs. 5a-c

Globorotalia spinulosa Cushman, 1927, Contr. Cushman Lab. Foram. Res., vol. 3, p. 114, pl. 23, figs. 4a-c; Howe, 1939, Louisiana Dept. Cons., Geol. Bull. 14, p. 85, pl. 12, figs 10-12; Loeblich, Tappan, and Bolli, 1957, U. S. Nat. Mus., Bull. 215, p. 168, pl. 38, figs. 6, 7.

Test small, thick, consisting of two whorls in a low trochospiral arrangement, unequally biconvex, ventral side more strongly convex than the dorsal side, periphery with a spinose keel present on the last three chambers, broadly rounded in the early portion, becoming acute; chambers closely appressed, about 10 in number, five in the last whorl, compressed on the dorsal side, inflated, and rapidly enlarging on the ventral side; sutures curved, radial, becoming oblique in adult chambers, slightly depressed on the dorsal side, ventral sutures straight, radial, strongly depressed; wall hyaline, medium perforate, ornamented with small spines which become more prominent near the periphery; aperture umbilical-extraumbilical, a low elongate slit, bordered by a distinct lip at the base of the last chamber. Height, 0.30 mm.; width, 0.25 mm.; thickness, 0.18 mm.

Rare. Castle Hayne formation, at Natural Well.

The species occurs with little variation in the upper five feet of the formation.

Plesiotype.—U.N.C. Cat. No. 3411.

Genus **CANCRIS** Montfort, 1808

Cancris communis Cushman and Todd Pl. 38, figs. 2a-c

Pulvinulina sagra Cushman, 1918 (not d'Orbigny), U. S. Geol. Sur., Bull. 676, p. 65, pl. 22, fig. 3; pl. 23, fig. 1.

Cancris sagra Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 56, pl. 11, figs. 4a-c; Cushman and Ponton, 1932, Florida Geol. Sur., Bull. 9,

p. 94, pl. 14, figs. 3a-c; Ellisor, 1940, Amer. Assoc. Pet. Geol., Bull., vol. 24, p. 474, pl. 6, fig. 6.

Cancris sagra communis Cushman and Todd, 1942, Contr. Cushman Lab. Foram. Res., vol. 18, p. 79, pl. 19, figs. 8-11; pl. 20, figs. 1a-c; Dorsey, 1948, Maryland Dept. Geol., Mines, Water Res., Bull. 2, p. 312, pl. 37, figs. 10a-c.

Test higher than wide, unequally biconvex, periphery acute, smooth in early portion, becoming lobulate in last two chambers; chambers few, six in the adult whorl, increasing rapidly in size as added; sutures on the dorsal side slightly depressed, gently curved, ventral sutures more strongly depressed and nearly radial; wall smooth, hyaline, finely perforate, with a transparent imperforate space above the aperture on the ventral side; aperture a low arch with slight lip. Height, 0.33 mm.; width, 0.22 mm.; thickness, 0.12 mm.

Rare. Duplin marl, at Natural Well and Barwick farm.

The Duplin marl specimens are identical with those described by Cushman and Ponton (1932, p. 94, pl. 14, fig. 3a-c) from the Choctawhatchee formation of Florida. The specimens exhibit both dextral and sinistral coiling.

Plesiotype.—U.N.C. Cat. No. 3457.

Cancris involutus, new species Pl. 30, figs. 1a-c

Test elongate, unequally biconvex, dorsal side flattened, involute, terminal chamber extending over umbilicus, ventral side convex, less involute, terminal chamber only partially embracing umbilicus, periphery lobulate, acute, with a narrow keel; chambers nine in number, increasing rapidly in size as added; sutures distinct with medium thin limbation, curved, flush with the surface in the early portion; wall hyaline, finely perforate; aperture a low arch slit extending from the umbilicus on the ventral side to slightly over the periphery nearly to the dorsal edge, with a slight lip. Height, 0.45 mm.; width, 0.33 mm.; thickness, 0.18 mm.

Common. Castle Hayne formation, at Natural Well.

This species occurs in the upper eight feet of the formation and ranges in size from 0.39 mm.—0.73 mm. The chamber count varies from seven-nine, with eight being the most common number. Sinistrally coiled forms occur most abundantly in a ratio of 2:1. This species is *Cancris*-like, but the clear area over the umbilicus, characteristic of the genus, is not visible and both the dorsal and ventral sides of the species are involute.

Cancris involutus differs from *C. sagra communis* Cushman and Todd (1942, p. 79, pl. 20, figs. 1a-c) in the involute dorsal and ventral sides and from *C. mauryae* Cushman and Renz (1942, Contr. Cushman Lab. Foram. Res., vol. 18, p. 11, pl. 2, figs. 17a-c) in the less limbate sutures, fewer chambers, smaller size, and less prominent extension of the terminal chamber over the umbilicus.

Holotype.—U.N.C. Cat. No. 3398.

Genus **VALVULINERIA** Cushman, 1926

Valvulineria danvillensis (Howe and Wallace) Pl. 30, figs. 2a-c

Gyroidina danvillensis Howe and Wallace, 1932, Louisiana Dept. Cons., Geol. Bull. 2, p. 69, pl. 13, figs. 3a-c.

Test small, thick, trochospiral, consisting of two whorls, dorsal side flattened, ventral side strongly convex, umbilicate, nearly circular in side view, periphery smooth, not lobulate, broadly rounded; chambers distinct, closely appressed, increasing gradually in size, seven in the last whorl; sutures on the dorsal side slightly curved and oblique to the periphery, flush with the surface in the early portion, becoming slightly depressed, sutures on the ventral side nearly straight, radial, slightly depressed; wall hyaline, finely perforate; aperture a low arch at the base of the apertural face extending from the periphery into the umbilicus, with a lip becoming more flanged toward the ventral umbilicus to form a short broad valve. Diameter, 0.30 mm.; thickness, 0.24 mm.

Abundant. Castle Hayne formation, at Natural Well.

The specimens occur abundantly throughout the formation with essentially no variation except for size which ranges from 0.24 mm.—0.30 mm. The valvular lip appears to be easily damaged and is not preserved in all specimens. Dextrally and sinistrally coiled forms occur in equal numbers.

Valvulineria octocamerata (Cushman and Hanna) also occurs abundantly and resembles this species in some respects but differs in the lobulate periphery, more prominent valvular lip, proportionately larger ultimate chambers, thinner test, less closely appressed chambers, and subcircular test.

Plesiotype.—U.N.C. Cat. No. 3449.

Valvulineria octocamerata (Cushman and Hanna) Pl. 30, figs. 3a-c

Gyroidina soldanii octocamerata Cushman and Hanna, 1927, California Acad. Sci., Proc., ser. 4, vol. 16, p. 223, pl. 14, figs. 16-18; Cushman, 1935, U. S. Geol. Sur., Prof. Paper 181, p. 45, pl. 18, figs. 4a-c; Howe, 1939, Louisiana Dept. Cons., Geol. Bull. 14, p. 75, pl. 9, figs. 34-36; Cushman, 1946, Cushman Lab. Foram. Res., Spec. Pub. 16, p. 31, pl. 6, fig. 15.

Valvulineria octocamerata Bandy, 1949, Bull. Amer. Paleont., vol. 32. No. 131, p. 84, pl. 13, figs. 1a-c.

Test small, trochospiral, consisting of two whorls, dorsal side flattened, ventral side strongly convex, umbilicate, periphery broadly rounded, slightly lobulate; chambers distinct, closely appressed, increasing gradually in size as added, six in the adult whorl; sutures on the dorsal side radial, slightly curved, flush with the surface in the early portion, becoming depressed; wall hyaline, finely perforate; aperture a low arch at the base of the apertural face extending from the periphery into the umbilicus, under a thin valvular lip which partially covers the umbilicus. Diameter, 0.34 mm.; thickness, 0.21 mm.

Abundant. Castle Hayne formation, at Natural Well.

This species occurs abundantly throughout the formation with only minor variation. The forms range from 0.26 mm.—0.35 mm. in diameter and in number of chambers from six-eight, with seven being the most common number. Dextral and sinistrally coiled forms occur in equal abundance.

Plesiotype.—U.N.C. Cat. No. 3450.

Valvulineria texana Cushman and Ellisor Pl. 30, figs. 4a-c

Valvulineria texana Cushman and Ellisor, 1931, Contr. Cushman Lab. Foram. Res., vol. 7, p. 56, pl. 7, figs. 9a-c; Howe and Wallace, 1932, Louisiana Dept. Cons., Geol. Bull. 2, p. 70, pl. 13, figs. 6a, 6b; Bergquist, 1942, Mississippi Geol. Sur., Bull. 49 (Fossils), p. 85, pl. 8, figs. 24, 25; Cushman, 1946, Cushman Lab. Foram. Res., Spec. Pub. 16, p. 31, pl. 6, fig. 13; Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 84, pl. 13, figs. 5a-c.

Test small, longer than wide, periphery broadly rounded, slightly lobulate; chambers slightly inflated, distinct, five in the adult whorl, with a valvular extension of the last chamber covering the umbilicus on the ventral side; dorsal sutures gently curved and slightly oblique, flush with the surface in the early portion, becoming slightly depressed; wall hyaline, smooth, finely perforate; aperture an elongate slit below the valvular lip. Diameter, 0.30 mm.; thickness, 0.14 mm.

Abundant. Castle Hayne formation, at Natural Well.

Specimens occur abundantly throughout the formation with almost no variation except for slight variation in the valvular extension of the last chamber on the ventral side. In some specimens the valvular extension does not completely cover the umbilicus. Dextral and sinistrally coiled forms occur in equal numbers.

Plesiotype.—U.N.C. Cat. No. 3451.

Genus **BUCCELLA** Andersen, 1952

Buccella depressa Andersen Pl. 38, figs. 3a-c, 4a-b

Eponides peruvianus Cushman and Parker, 1931 (not d'Orbigny), U. S. Nat. Mus., Proc., vol. 80, art. 3, No. 2903, p. 19.

Buccella depressa Andersen, 1952, Washington Acad. Sci., Jour., vol. 42, No. 5, p. 145, figs. 7, 8, (Figures of Cushman's and Parker's original specimens); McLean, 1956, Bull. Amer. Paleont., vol. 36, No. 160, p. 355, pl. 50, figs. 2-4.

Test small, trochoid, subequally biconvex, periphery subacute, slightly lobulate, dorsal side evolute, smooth, ventral side involute. with umbilical area covered by opaque pustulose material; chambers flattened on the dorsal surface, three whorls visible, chambers inflated on the ventral side, seven in the last whorl; sutures depressed, oblique to the peripheral margin on the dorsal side, more strongly depressed and radial on the ventral side, covered with opaque pustulose material which extends outward along the sutures from the umbilicus; wall hyaline, finely perforate; aperture a low narrow slit at the base of the apertural face, partially covered by pustulose material; slitlike supplementary apertures visible toward the outer ventral sutural margin of each chamber. Diameter, 0.34 mm.; thickness, 0.19 mm.

Common. Duplin marl, at Natural Well and Barwick farm.

The sutures on the dorsal side of these specimens vary somewhat. Some of the forms have slightly oblique dorsal sutures and in others the dorsal sutures are radial.

Plesiotype.—U.N.C. Cat. No. 3493. Described specimen.

Plesiotype.—U.N.C. Cat. No. 3494. Specimen with less oblique dorsal sutures.

Genus **ALABAMINA** Toulmin, 1941

Alabamina mississippiensis Todd Pl. 31, figs. 1a-c

Pulvinulinella obtusa Cushman and Todd, 1945 (not Burrows and Holland), Contr. Cushman Lab. Foram. Res., vol. 21, pt. 4, p. 101, pl. 16, figs. 7, 8; Cushman, 1946, Cushman Lab. Foram. Res., Spec. Pub. 16, p. 36, pl. 7, figs. 7, 8.
Alabamina wilcoxensis Cushman and Todd, 1948 (not Toulmin), Contr. Cushman Lab. Foram. Res., vol. 24, p. 10.
Alabamina mississippiensis Todd, 1952, U. S. Geol. Sur., Prof. Paper 241, p. 42, pl. 6, figs. 8a-c.

Test subcircular, dorsal side slightly convex, ventral side more strongly convex, periphery slightly lobulate; chambers flat, five in the last whorl; sutures on the dorsal side indistinct, slightly curved, flush with the surface, tangential to the periphery, ventral sutures distinct, radial, only slightly curved and depressed; wall hyaline, finely perforate; aperture a slit at the base of the septal face extending from the periphery of the apertural fold nearly to the umbilicus. Diameter, 0.32 mm.; thickness, 0.18 mm.

Rare. Castle Hayne formation, at Natural Well.

Plesiotype: U.N.C. Cat. No. 3394.

Genus **STREBLUS** Fischer, 1817

Streblus beccarii parkinsoniana (d'Orbigny) Pl. 39, figs. 1a-c

Rosalina parkinsoniana d'Orbigny, 1839, Foraminifères, in de la Sagra, Histoire physique, politique et naturelle de l'ile de Cuba, p. 99, pl. 4, figs. 25-27.
Rotalia beccarii (Linné) var. *parkinsoniana* Cushman and Cole, 1930, Contr. Cushman Lab. Foram. Res., vol. 6, p. 100, pl. 13, fig. 14; Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 56, pl. 11, figs. 3a-c; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 31, pl. 11, figs. 3a-c.
Streblus beccarii (Linné) var. *parkinsoniana* Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Pub. 25, p. 233, pl. 15, figs. 43-45.
"*Rotalia*" *beccarii* (Linné) var. *parkinsoniana* Phleger and Parker, 1951, Geol. Soc. Amer., Mem. 46, pt. 2, p. 23, pl. 12, figs. 6a, 6b.

Test circular, biconvex, periphery acutely rounded, lobulate, umbilicus on the ventral side depressed, containing a small boss of clear shell material; early chambers flat, later chambers slightly inflated on the dorsal side, two whorls visible, chambers inflated on the ventral side, eight in the adult whorl, inner margins of ventral chambers irregular; sutures curved, radial, distinct, depressed, slightly limbate; wall hyaline, finely perforate; aperture a high arch at the base of the apertural face between the periphery and inner margin of the terminal chamber. Diameter, 0.33 mm.; thickness, 0.15 mm.

Common at Natural Well, abundant at Barwick farm. Duplin marl.

The Duplin marl specimens range in diameter from 0.30 mm. —0.45 mm. with from eight-ten chambers, eight being the most common. Sinistrally coiled forms occur more abundantly in a ratio of 3:2. These forms seem to be identical with those identified by Cushman and Cahill (1933, p. 31, pl. 11, figs. 3a-c) and by Phleger and Parker (1951, p. 23, pl. 12, figs. 6a, 6b).

Plesiotype.—U.N.C. Cat. No. 3487.

Genus **CIBICIDINA** Bandy, 1949

Cibicidina blanpiedi (Toulmin) Pl. 31, figs. 2a-c

Cibicides blanpiedi Toulmin, 1941, Jour. Paleont., vol. 15, p. 609, pl. 82, figs. 11-13.
Cibicidina blanpiedi Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 91, pl. 15, figs. 4a-c.

Test subcircular, plano-convex, dorsal side flat, slightly evolute, ventral side conical, involute, periphery smooth, keeled, with an acute peripheral angle; chambers distinct, closely appressed, nine in the final whorl, flat on the dorsal side, inflated on the ventral side, with each succeeding chamber extending slightly over those preceding it; sutures on the dorsal side limbate, flush with the surface, strongly curved, radial, ventral sutures sigmoid in shape, radial, flush with the surface; wall hyaline, finely perforate; aperture a low arch on the periphery, bordered by a definite lip, restricted to the peripheral area, extending to the dorsal side as a slit at the inner margin of the last two chambers. Diameter, 0.28 mm.; thickness, 0.21 mm.

Abundant. Castle Hayne formation, at Natural Well.

The species occurs with only slight variation throughout the formation. Sinistrally coiled forms occur most abundantly in a ratio of 2:1.

Plesiotype.—U.N.C. Cat. No. 3400.

Cibicidina cooperensis (Cushman) Pl. 31, figs. 3a-c

Cibicides cooperensis Cushman, 1933, Contr. Cushman Lab. Foram. Res., vol. 9, p. 20, pl. 2, figs. 11a-c; Cushman, 1935, U. S. Geol. Sur., Prof. Paper 181, p. 53, pl. 23, figs. 3a-c.

Test subcircular, concavo-convex, dorsal side slightly concave, involute, embracing about three-fourths of the earlier whorls, ventral side convex with small depressed umbilical plug, periphery round to subacute, slightly lobulate in the later portion; chambers distinct, 8½ in the last whorl, closely appressed, inner margins of the chambers on the dorsal side irregular in shape, extending as valvelike projections into the umbonal region; sutures radial, curved, slightly depressed in the last few chambers; wall hyaline, finely perforate; aperture a low arch on the periphery, extending to the dorsal side as a slit at the base of the inner margin of the last chamber with a thin lip. Diameter, 0.40 mm.; thickness, 0.14 mm.

Rare. Castle Hayne formation, at National Well.

This species is here assigned to the genus *Cibicidina* Bandy, 1949 because of the involute character of both sides of the test and the fine perforations. The Castle Hayne specimens differ from the type in the smaller size, slightly thinner test, more strongly curved sutures, and less lobulate periphery.

Plesiotype.—U.N.C. Cat. No. 3401.

Cibicidina minuta, new species Pl. 31, figs. 4a-c

Test minute, involute, plano-convex, subcircular in outline, dorsal side flat to slightly concave, ventral side convex with a central small boss in edge view; periphery smooth, back flat, oblique to dorsal edge, with a distinct narrow keel at dorsal margin; chambers numerous, nine in the last whorl, extensions of the inner margins extending almost to the center on the dorsal side, enlarging gradually in size as added; sutures distinct, limbate, strongly recurved, flush with the surface on both sides; wall hyaline, finely perforate; aperture a low arch on the periphery at the base of the apertural face, bordered by a distinct lip, and extending on the dorsal side as a slit at the base of the last chamber for a distance of 1-2 chambers. Diameter, 0.27 mm.; thickness, 0.11 mm.

Common. Castle Hayne formation, at Natural Well.

This species occurs throughout the formation with almost no variation in size. The forms have from eight-ten chambers, with eight being the most common. Dextral and sinistrally coiled forms occur in equal abundance.

Cibicidina danvillensis (Howe and Wallace) (1932, p. 77, pl. 14, fig. 5a-c), resembles this species but differs in the much larger size, fewer chambers, less strongly recurved sutures, thinner test, and lower arched aperture.

Holotype.—U.N.C. Cat. No. 3402.

Genus **DISCORBIS** Lamarck, 1804

Discorbis duplinensis, new species Pl. 39, figs. 2a-c, 3a-c

Test higher than broad, dorsal side slightly evolute, convex, ventral side involute, slightly concave, periphery lobulate, subacute; chambers slightly inflated, seven in the last whorl; sutures distinct, curved, radial, limbate in the early portion dorsally, becoming depressed in the later portion, ventral sutures slightly depressed; wall hyaline, coarsely perforate on the dorsal side, coarsely perforate near the periphery on the ventral side becoming finely perforate in the umbilicus; aperture ventral, a low arch slit near the umbilicus with a slight lip. Diameter, 0.47 mm.; thickness, 0.18 mm.

Abundant. Duplin marl, at Natural Well and Barwick farm.

This species is the most abundant Foraminifera in the Duplin marl of Duplin County, North Carolina, and should prove to be an excellent guide fossil. Dextral and sinistral forms occur with the same degree of abundance.

Discorbis duplinensis can be readily distinguished from *Discorbis warreni* Dorsey (1948, p. 310, pl. 37, fig. 5a-c) by the partially evolute character of the dorsal side, as opposed to an involute dorsal coil in *D. warreni,* and the more distinct sutures. *Discorbis floridana* Cushman (1922, Carnegie Inst. Washington, Pub. 311, p. 39, pl. 5, figs. 11, 12) differs in that it has fewer chambers, indistinct ventral sutures, and is evolute dorsally.

Holotype.—U.N.C. Cat. No. 3462 (figs. 2a-c).

Paratype.—U.N.C. Cat. No. 3463 (figs. 3a-c).

Discorbis terquemi (Rzehak) Pl. 39, figs. 4a-c

Rosalina orbicularis Terquem, 1876, (=junior homonym of *R. orbicularis* d'Orbigny, 1850), Anim. sur la Plage de Dunkerque, p. 75, pl. 9, figs. 4a, 4b.

Discorbina orbicularis Brady, 1884, *Challenger* Rept., Zoology, vol. 9, p. 647, pl. 88, figs. 4-8.

Discorbina terquemi Rzehak, (new name for *Rosalina orbicularis* Terquem, not d'Orbigny), 1888, Geol. Reichsanst. Verh., Austria, No. 11, p. 228.

Discorbis orbicularis Cushman, 1915, U. S. Nat. Mus., Bull. 71, pt. 5, p. 16, pl. 11, fig. 1; Cushman, 1931, *ibid.*, Bull. 104, pt. 8, p. 27, pl. 6, figs. 3a-c; Cushman and Ponton, 1932, Florida Geol. Sur., Bull. 9, p. 89, pl. 13, figs. 6a-c.

Discorbis mira Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 52, pl. 10, figs. 2a-c.

Discorbis terquemi Puri, 1953, Florida Geol. Sur., Bull. 36, p. 131.

Test small, trochoid, subcircular in outline, convexo-concave, dorsal side forming a low cone, ventral side flattened to concave, periphery subacute with a slight keel; chambers flattened, four in the adult whorl, with a slight lobate extension of the ventral test wall projecting inward over the aperture; sutures on the dorsal side strongly oblique, curved, flush with the surface or slightly raised, ventrally depressed, almost radial; wall hyaline, finely perforate; aperture an elongate, slightly arched slit under each outer chamber, extending into the umbilicus. Diameter, 0.26 mm.; thickness, 0.10 mm.

Common. Duplin marl, at Natural Well and Barwick farm.

Plesiotype.—U.N.C. Cat. No. 3464.

Discorbis turritus Cushman Pl. 40, figs. 1a-c

Discorbis turrita Cushman, 1918, U. S. Geol. Sur., Bull. 676, p. 59, pl. 14, fig. 2; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 30, pl. 10, figs. 6a-c; McLean, 1956, Bull. Amer. Paleont., vol. 36, No. 160, p. 353, pl. 47, figs. 2a-d.

Test small, subcircular in outline, trochoid, convexo-concave, periphery slightly lobulate, dorsal side forms a medium cone, ventral side concave; chambers slightly inflated, closely appressed on the dorsal side, extending nearly to the center of the umbilicus on the ventral side, five compose the last whorl; sutures slightly depressed, curved, oblique on the dorsal side, ventral sutures curved, radial, depressed; wall hyaline, finely perforate; aperture ventral, extends as a low arch from the periphery to the umbilicus, bordered by a definite lip. Diameter, 0.33 mm.; thickness, 0.18 mm.

Rare. Duplin marl, at Natural Well.

This species was described by Cushman (1918, p. 59, pl. 14, fig. 2) from the Yorktown formation of Virginia and differs from the Duplin marl specimens in having a "definite keel on the ventral side," but no keel is illustrated in apertural or dorsal views; otherwise the forms are identical with the type figure. McLean, in 1956, figured a specimen identified by him (p. 353, pl. 47, fig.

2a-d) as *Discorbis turrita* Cushman, which this author believes to be improperly identified even to genus.

Plesiotype.—U.N.C. Cat. No. 3465.

Genus **ANOMALINA** d'Orbigny, 1826

Anomalina umbonata Cushman Pl. 32, figs. 1a-c

Anomalina umbonata Cushman, 1925, Amer. Assoc. Pet. Geol., Bull., vol. 9, p. 300, pl. 7, figs. 5, 6; Cushman, 1927, Jour. Paleont., vol. 1, p. 170, pl. 27, figs. 10, 11; Howe, 1939, Louisiana Dept. Cons., Geol. Bull. 14, p. 86, pl. 13, figs. 6-8; Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 102, pl. 18, figs. 3a-c.

Test plano-convex, dorsal side slightly concave with a central spiral umbonate mass, ventral side convex with a distinct umbo of clear shell material, periphery rounded, smooth in the early portion becoming lobulate; chambers 10 in number in the final whorl, closely appressed, inflated in the later portion; sutures curved, radial, early sutures limbate, flush with the surface, becoming depressed and nonlimbate in the later portion, inner edges of dorsal sutures fused in the early portion giving rise to the spiral umbonate mass in the umbilical region; wall hyaline, medium perforate; aperture a low arch on the periphery at the base of the last chamber, extending to the dorsal side between the whorls for a distance of at least one chamber. Diameter, 0.36 mm.; thickness, 0.15 mm.

Abundant. Castle Hayne formation, at Natural Well.

The species occur with only slight variation in all the samples. The size and prominence of the umbo varies. Dextrally coiled forms occur most abundantly in a ratio of 5:2.

Plesiotype.—U.N.C. Cat. No. 3396.

Genus **CIBICIDES** Montfort, 1808

Cibicides americanus (Cushman) Pl. 40, figs. 2a-c

Truncatulina americana Cushman, 1918, U. S. Geol. Sur., Bull. 676, p. 63, pl. 20, figs. 2, 3; pl. 21, fig. 1. (Not Cushman, 1918, U. S. Nat. Mus., Bull. 103, p. 68, pl. 23, fig. 2.)

Cibicides americanus Cole and Gillespie, 1930, Bull. Amer. Paleont., vol. 15, No. 57b, p. 14, pl. 4, fig. 4; Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 61, pl. 12, figs. 5a-c; Cole and Ponton, 1930, *ibid.*, Bull. 5, p. 48, pl. 7, figs. 5, 6; Cushman and Parker, 1931, Contr. Cushman Lab. Foram. Res., vol. 7, p. 15, pl. 3, figs. 1a-c; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 34, pl. 13, figs. 2a-c.

Test plano-convex, dorsal side flat, ventral side convex, periphery subacute, lobulate, early portion with a slight keel; chambers eight in number, increasing rapidly in size; sutures on the dorsal side flush with the surface, curved; sutures on the ventral side slightly depressed, curved; wall smooth, hyaline, finely perforate; aperture on the periphery, a low arch, extending to the dorsal side, bordered by a distinct lip. Height, 0.60 mm.; width 0.45 mm.; thickness, 0.21 mm.

Abundant. Duplin marl, at Natural Well and Barwick farm.

Duplin marl species range in size from 0.30 mm.—0.75 mm. in height and both sinistral and dextral forms are present in the fauna with no apparent preference.

Plesiotype.—U.N.C. Cat. No. 3459.

Cibicides duplinensis, new species Pl. 40, figs. 3a-c

Test subcircular in outline, plano-convex, dorsal side flat, periphery smooth, subacute; chambers numerous, 10 in the adult whorl, early chambers concealed dorsally by coarsely perforate secondary umbilical material; sutures broad, distinct, curved, flush with the surface in the early portion of the adult whorl, slightly depressed in the later portion, fusing together in the umbilicus on the ventral side; wall hyaline, fine to medium perforate on the ventral side, coarsely perforate on the dorsal side; aperture on the periphery, a low arch slit bordered by a distinct lip and extending onto the dorsal side. Diameter, 0.30 mm.; thickness, 0.12 mm.

Abundant. Duplin marl, at Natural Well and Barwick farm.

This species coils both sinistrally and dextrally with no apparent preference for either, and the chambers vary in number from eight-ten. The largest specimen found has a diameter of 0.39 mm. and the smallest, a diameter of 0.27 mm. One or several of the adult chambers may be aberrantly lobulate.

This species resembles *Cibicides floridanus* (Cushman), (see *Truncatulina floridana* Cushman, 1918, U. S. Geol. Sur., Bull. 676, p. 62, pl. 19, figs. 2a-c) but differs in that it has fewer chambers, lacks a keel, has flush to slightly depressed sutures, is smaller in size, and has distinct differences in the pore sizes of the dorsal and ventral test walls.

Holotype.—U.N.C. Cat. No. 3460.

Cibicides eccentricus, new species Pl. 40, figs. 4a-c

Cibicides lobatulus Todd, 1952 (not Walker and Jacob), U. S. Geol. Sur., Prof. Paper 241, p. 45, pl. 6, figs. 19a, 19b.

Test probably attached, shape irregular, compressed, plano-convex, dorsal side evolute, flat, ventral side convex, partially evolute, periphery gently rounded, with strong irregular lobulation; chambers elongate; flattened on the dorsal side, inflated on the ventral side, expanding rapidly in height and length as added, seven in the adult whorl; sutures distinct, depressed, slightly curved in the early portion, becoming strongly curved; wall hyaline, medium perforate; aperture a low arch with a definite lip on the periphery extending for a distance of one-half chamber on the dorsal side; former apertures visible on the dorsal side at the inner margins of the chambers in the last whorl. Height, 0.61 mm.; width, 0.58 mm.; thickness, 0.16 mm.

Common. Duplin marl, at Natural Well and Barwick farm.

Cibicides eccentricus is probably an attached form and as a result the specimens are variable in shape, size, and number of chambers. The dorsal side of some forms is strongly curved indicating possible attachment to a plant stem or irregular object. The holotype is higher than wide, but the reverse situation exists in other specimens.

The persistent characters of this species are the elongate chambers, lobulate periphery, partially evolute ventral side in most specimens, and the nature and position of the aperture and former apertures.

The species fits into the general category of forms described as *Cibicides lobatulus* (Walker and Jacob), by Todd, *et al.* (See Todd, 1952, p. 45 for a complete listing). The type figure (*Nautilus lobatulus* Walker and Jacob, 1798) in Adams Essays on the Microscope. (Kanmacher's ed., p. 642, pl. 14, fig. 36) is unrecognizable and the type description is inadequate. The type figure of *C. lobatulus* (Walker and Jacob) indicates a uniformly coiled specimen with strong regular lobulation and with a completely involute ventral side and totally evolute dorsal side. *C. eccentricus* is only partially involute dorsally and ventrally with slightly stronger involution on the ventral side. Because of the confusion in the literature regarding the appearance of *C. lobatulus* (Walker and Jacob) and the impossibility of comparing specimens with the type figure and description, the name *C. eccentricus* is proposed for the forms found in the Duplin marl.

Holotype.—U.N.C. Cat. No. 3461.

Cibicides praecipuus, new species Pl. 32, figs. 2a-c

Test probably attached, shape irregular, compressed, plano-convex, dorsal side evolute, flat, ventral side convex, involute, periphery subacute, slightly lobulate, with a distinct narrow keel; chambers distinct, closely appressed, flattened on the dorsal side, inflated on the ventral side, enlarging gradually in height as added, seven in the last whorl; sutures radial, curved, limbate, flush with the surface in the early portion becoming slightly depressed in the last two or three chambers; wall hyaline, medium perforate; aperture a low arch with a definite lip, extending from the periphery for a distance of one-half chamber on the dorsal side; former apertures visible on the dorsal side at the inner margins of the chambers in the last whorl. Height, 0.45 mm.; width, 0.33 mm.; thickness, 0.15 mm.

Abundant. Castle Hayne formation, at Natural Well.

This species occurs throughout the formation with wide variation in shape, size, and number of chambers. The variation may be attributed to its attached mode of life, which is suggested in some specimens by highly curved, concavo-convex, elongate tests. The forms range from 0.36 mm.—0.75 mm. in height and in number of chambers from six-ten, seven being the most common.

The persistent characters of this species are the distinct narrow keel, closely appressed chambers, involute ventral side, and the nature and position of the aperture and former apertures.

Cibicides praecipuus differs from *C. sublobus* (Cushman) (see *Truncatulina subloba* Cushman, 1918, p. 62, pl. 19, figs. 1a-c) in the more tightly coiled chambers, low arched aperture, and limbate distinct sutures. *C. eccentricus* Copeland, n. sp. differs in the more elongate chambers, nonlimbate sutures, partially evolute ventral side, and thinner test in relation to overall height.

Holotype.—U.N.C. Cat. No. 3399.

Genus **EPONIDES** Montfort, 1808

Eponides cocoaensis Cushman Pl. 32, figs. 3a-c

Eponides cocoaensis Cushman, 1928, Contr. Cushman Lab. Foram. Res., vol. 4, p. 73, pl. 10, figs. 2a-c; Cushman, 1935, U. S. Geol. Sur., Prof. Paper 181, p. 47, pl. 19, figs. 1a-c, 2a-c; Cushman, 1946, Cushman Lab. Foram. Res., Spec. Pub. 16, p. 34, pl. 6, fig. 16.

Test large, stout, biconvex, biumbonate, circular in side view, periphery acute, slightly irregular, with a distinct keel; chambers numerous, 10 in the adult whorl, early chambers concealed dorsally by perforate secondary umbilical material; sutures on the dorsal side curved, limbate, slightly oblique, flush with the surface, ventral sutures limbate, raised, strongly curved, radial, fusing together in the umbonal region; wall hyaline, medium perforate; aperture a low slit, bordered by a distinct lip on the ventral side, extending slightly on the dorsal side. Diameter, 0.67 mm.; thickness, 0.30 mm.

Rare. Castle Hayne formation, at Natural Well.

The specimens range from 0.35 mm.—0.67 mm. in diameter with from eight-ten chambers. The degree of umbonation varies in the Castle Hayne specimens from large and pronounced to small. Species illustrated by Cushman (1935, pl. 19, figs. 1, 2) also have umbos of varying sizes. The Castle Hayne forms differ from the type in the thinner test, more equally biconvex test, and more prominent umbos.

Plesiotype.—U.N.C. Cat. No. 3406.

Genus **SIPHONINA** Reuss, 1850

Siphonina danvillensis Howe and Wallace Pl. 33, figs. 1a-c

Siphonina danvillensis Howe and Wallace, 1932, Louisiana Dept. Cons., Geol. Bull. 2, p. 70, pl. 13, figs. 1a, 1b; Bergquist, 1942, Mississippi Geol. Sur., Bull. 49 (Fossils), p. 89, pl. 9, figs. 3a-c; Cushman, 1946, Cushman Lab. Foram. Res., Spec. Pub. 16, p. 35, pl. 7, figs. 3, 4; Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 115, pl. 21, figs. 8a-c.

Test biconvex, trochospiral, completely involute ventrally, evolute dorsally, periphery acute, slightly lobulate, with a thin striate keel; chambers distinct on the ventral side, indistinct on the dorsal side, especially in the spire, five in the last whorl; sutures on the ventral side slightly curved, radial, somewhat depressed, dorsal sutures oblique to the periphery, only slightly depressed, indistinct; wall hyaline, coarsely perforate; aperture elongate, elliptical, positioned more toward the ventral side, at the end of a distinct short neck, with a broad flaring lip. Diameter, 0.35 mm.; thickness, 0.16 mm.

Abundant. Castle Hayne formation, at Natural Well.

This species occurs throughout the formation with only slight variation except for size which varies from 0.24 mm.—0.44 mm. in diameter. Sinistrally coiled forms occur more abundantly in a ratio of 2:1. The type figure illustrates a specimen with a denticulate keel which occurs in some of the Castle Hayne specimens and is dependent upon preservation. Perfectly preserved specimens have smooth, striate keels, and slightly damaged specimens have denticulate keels. There is slight variation in the keel widths of the specimens; in some the keel is well developed and broad and in others is almost lacking.

Plesiotype.—U.N.C. Cat. No. 3442.

Genus **PLANORBULINELLA** Cushman, 1927

Planorbulinella perforata, new species Pl. 41, figs. 1a-b, 2a-b, 3a-b

Acervulina sp. cf. *A. inhaerens* Cushman, 1933 (not Schultze), U. S. Geol. Sur., Prof. Paper 175-A, p. 35, pl. 13, figs. 6, 7.

Test thin, discoidal, attached, flat, slightly concave or folded on the attached dorsal side, convex on the ventral side, bordered by a narrow keel visible on the dorsal side; chambers inflated, increasing gradually in size as added, arranged in an annular series, those of each series alternating with those of the adjacent ones; sutures slightly depressed on the dorsal side, strongly depressed ventrally; wall hyaline, coarsely perforate, with granular material scattered about the test, mainly in the central portion; apertures on the periphery, one at each end of alternate chambers in the last whorl, bordered by distinct lips. Length, 0.80 mm.; thickness, 0.20 mm.

Abundant. Duplin marl, at Natural Well and Barwick farm.

The specimens are variable in size, shape, amount of granular material present on the test, and the relative number and sizes of the chambers. Many of the forms seem to be fragmentary portions of once larger specimens and this, plus the apparent attached method of growth, accounts for variation in the size and shape of the tests. Granular material is more common in the centers of gerontic specimens than in the centers of younger forms.

The two paratypes (Pl. 41, figs. 2a-3b) represent the extremes in variation within the species. Figures 2a, 2b, illustrate a specimen which lacks a keel and has numerous small chambers. Figures 3a, 3b, illustrate a specimen with a few greatly enlarged chambers which lack granular material. A narrow keel is visible on the dorsal side of this specimen.

The specimens figured by Cushman and Cahill (1933, p. 35, pl. 13, fig. 6, 7) are from the Barwick farm locality and do not show the apertures which are present in complete specimens.

Holotype.—U.N.C. Cat. No. 3477 (figs. 1a-b).
Paratype.—U.N.C. Cat. No. 3480 (figs. 2a-b).
Paratype.—U.N.C. Cat. No. 3481 (figs. 3a-b).

Family **ORBULINIDAE Schultze, 1854**

Genus **GLOBIGERINA** d'Orbigny, 1826

Globigerina apertura Cushman Pl. 41, figs. 4a-c

Globigerina apertura Cushman, 1918, U. S. Geol. Sur., Bull. 676, p. 57, pl. 12, figs. 8a-c.

Test higher than wide, small, consisting of 2-2½ whorls arranged in a low trochospire; chambers few, inflated, about nine in number, four composing the last whorl, loosely appressed; sutures slightly depressed on the dorsal side, strongly depressed ventrally; wall conspicuously spinose; aperture a large semicircular opening into the umbilicus with a narrow lip. Height, 0.33 mm.; width, 0.27 mm.; thickness, 0.21 mm.

Rare. Duplin marl, at Natural Well and Barwick farm.

Plesiotype.—U.N.C. Cat. No. 3471.

Globigerina bulloides d'Orbigny Pl. 33, figs. 2a-c

Globigerina bulloides d'Orbigny, 1826, Ann. Sci. Nat., ser. 1, vol. 7, p. 277; d'Orbigny, 1839, Foraminifères, in Barker-Webb et Berthelot, Hist. Nat. Iles Canaries, pl. 2, figs. 1-3, 28; Howe and Wallace, 1932, Louisiana Dept. Cons., Geol. Bull. 2, p. 73, pl. 10, fig. 10; Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 119, pl. 23, figs. 5a-c; Loeblich, Tappan, and Bolli, 1957, U. S. Nat. Mus., Bull. 215, p. 31, pl. 4, figs. 1a-c; Banner and Blow, 1960, Contr. Cushman Found. Foram. Res., vol. 11, p. 3, pl. 1, figs. 1, 4.

Test small, higher than wide, consisting of two whorls arranged in a medium trochospire, subquadrate in dorsal and ventral views;

chambers spherical, about 10 in number, four visible on the ventral side, loosely appressed; sutures distinct, depressed; wall hyaline, medium perforate, slightly hispid; aperture a large opening into the umbilicus. Height, 0.24 mm.; width, 0.20 mm.; thickness, 0.18 mm.

Common. Castle Hayne formation, at Natural Well.

Dextrally coiled forms occur most abundantly in a ratio of 2:1. The species from Natural Well occur throughout the formation with little variation except in the size of the aperture, which varies from small and somewhat constricted to large and open. D'Orbigny (1839, pl. 2, fig. 2) illustrated the aperture of *G. bulloides* as being a restricted opening into the umbilicus and Loeblich, Tappan, and Bolli (1957, p. 31, pl. 4, fig. 1a-c) illustrated a large unrestricted aperture opening into the umbilicus. Both types of apertures occur in the Castle Hayne forms and they have the general appearance of forms identified as *G. bulloides.*

Plesiotype.—U.N.C. Cat. No. 3408.

Globigerina macrastoma, new species Pl. 41, figs. 5a-c

Test thick, higher than wide, consisting of three whorls in a low trochospiral arrangement; chambers inflated, globular, rapidly enlarging, about 14 in number, five in the last whorl, closely appressed; sutures radial, slightly depressed on the dorsal side, strongly depressed ventrally; wall medium perforate, cancellate, forming irregularly shaped depressions; aperture umbilical-extraumbilical, a large, elongate, semicircular opening bordered by a faint lip. Height, 0.36 mm.; width, 0.30 mm.; thickness, 0.27 mm.

Common. Duplin marl, at Natural Well and Barwick farm.

The amount of variation in this species is slight. The forms range from 0.27 mm.—0.39 mm. in height with from four—five chambers in the outer whorl. In a few specimens the lip becomes more pronounced.

Globigerina hexagona Natland (1938, Bull. Scripps Inst. Oceanography, vol. 4, No. 5, p. 149, pl. 7, fig. 1a-c) differs in the more strongly cancellate test and the low arched aperture.

Holotype.—U.N.C. Cat. No. 3472.

Globigerina protoreticulata Hofker Pl. 42, figs. 1a-c

Globigerina protoreticulata Hofker, 1956, Jour. Paleont., vol. 30, p. 954, text-fig. 95.

Globigerina sp. form A McLean, 1956, Bull. Amer. Paleont., vol. 36, No. 160, p. 362, pl. 52, figs. 1a-c.

Test higher than wide, consisting of 2½ whorls in a low trochospiral arrangement; chambers inflated, subspherical, rapidly enlarging, loosely appressed, about ten in number, four in the last whorl, the last chamber greatly enlarged; sutures distinct, strongly depressed; wall coarsely cancellate, forming polygonal, relatively deep depressions; aperture umbilical, a low narrow slit at the base of the last chamber. Height, 0.33 mm.; width, 0.27 mm.; thickness, 0.22 mm.

Rare. Duplin marl, at Barwick farm only.

The specimen identified by McLean (1956, p. 362) from the Yorktown formation of Virginia is similar and seems to belong in this species.

Plesiotype.—U.N.C. Cat. No. 3496.

Globigerina triloculinoides Plummer Pl. 33, figs. 3a-c; Pl. 42, figs. 2a-c

Globigerina triloba Egger, 1899, Abh. k. bay Akad. Wiss., Cl. 2, vol. 21, pt. 1, p. 171, pl. 21, fig. 8.

Globigerina bulloides Cushman, 1920, U. S. Geol. Sur., Prof. Paper 128, p. 69, pl. 11, fig. 6.

Globigerina triloculinoides Plummer, 1926, Univ. Texas Bull. 2644, p. 134, pl. 8, figs. 10a-c; Jennings, 1936, Bull. Amer. Paleont., vol. 23, No. 78, p. 35, pl. 4, fig. 10; Loeblich, Tappan, and Bolli, 1957, U. S. Nat. Mus., Bull. 215, p. 183, pl. 45, figs. 3a-c.

Test higher than wide, small, consisting of three whorls in a low trochospiral arrangement; chambers inflated, rapidly enlarging, about 12 in number, four composing the last whorl, loosely appressed; sutures depressed on both dorsal and ventral sides; wall medium perforate; aperture umbilical, a low broad slit at the base of the last chamber, bordered by a distinct narrow lip. Height, 0.27 mm.; width, 0.22 mm.; thickness, 0.17 mm.

Rare. Duplin marl at Barwick farm (Plate 42, figs. 2a-c) and Castle Hayne formation at Natural Well (Plate 33, figs. 3a-c).

The Castle Hayne specimens differ in the more closely appressed less globular chambers, and the umbilical-extraumbilical aperture. The dimensions of the Castle Hayne plesiotype: height, 0.28 mm.; width, 0.21 mm.; thickness, 0.21 mm.

Plesiotype.—U.N.C. Cat. No. 3497 Duplin marl.

Plesiotype.—U.N.C. Cat. No. 3409 Castle Hayne formation.

Genus **GLOBIGERINOIDES** Cushman, 1927

Globigerinoides cancellata, new species Pl. 42, figs. 3a-c

Test thick, higher than wide, shape subequal in all views, consisting of two whorls in a low trochospiral arrangement; chambers inflated, globular, loosely appressed, rapidly enlarging, about 10 in number, 3½ visible from the ventral side, last chamber large, equal to one half the test height; sutures distinct, strongly depressed; wall conspicuously cancellate, forming deep irregularly shaped depressions; primary aperture umbilical, a low elongate slit at the base of the last chamber, secondary sutural apertures prominent on the dorsal side. Height, 0.36 mm.; width, 0.30 mm.; thickness, 0.29 mm.

Common. Duplin marl, at Natural Well and Barwick farm.

Sinistral and dextral coiling occurs with an apparent preference for the dextral type; otherwise there is little variation in the forms.

This species resembles *Globigerinoides subquadrata* Bronnimann (1954 *in* Todd, *et al.,* Amer. Jour. Sci., vol. 252, No. 11, p 680, pl. 1, figs. 5, 8a-c) but differs in the greater chamber inflation. size of the last chamber, visible initial spire, lower primary aperture. and more distinct sutural apertures.

G. sacculiferous immatura LeRoy (Natuurk. Tijdschr. Nederl.-Indië, Batavia, Java, dl. 99, afl. 6, p. 263, pl. 3, figs. 19-21) differs in the larger size, elongate early chambers, noncancellate test, and high arched primary aperture with a distinct lip.

Holotype.—U.N.C. Cat. No. 3473.

Globigerinoides rubra (d'Orbigny) Pl. 42, figs. 4a-c

Globigerina rubra d'Orbigny, 1939, Foraminifères, in de la Sagra. Histoire, physique, politique et naturelle de l'ile de Cuba, p. 82, pl. 4, figs. 12-14.

Globigerinoides rubra Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Pub. 25, p. 281, pl. 21, fig. 52; Loeblich, Tappan, and Bolli, 1957, U. S. Nat. Mus., Bull. 215, p. 32, pl. 4, figs. 2a-c; Bolli, 1957, *ibid.*, p. 113, pl. 25, figs. 12a-13b.

Test thick, higher than wide, consisting of three whorls in a moderately high trochospiral arrangement; chambers inflated, globular to oval, loosely appressed, rapidly enlarging, about 12 in number, three chambers and a portion of the early stage visible from the ventral side; sutures distinct, depressed, radial; wall medium perforate, slightly hispid; primary aperture umbilical, large, semicircular, previous apertures remaining open into the umbilicus, with numerous secondary, smaller, sutural apertures. Height, 0.38 mm.; width, 0.27 mm.; thickness, 0.28 mm.

Abundant. Duplin marl, at Natural Well and Barwick farm.

The amount of variation in this species is slight. The forms range from 0.26 mm.—0.38 mm. high. In the smaller forms the secondary apertures are not well developed. Examples of sinistral and dextral coiling occur in equal abundance.

Plesiotype.—U.N.C. Cat. No. 3474.

Globigerinoides topilensis (Cushman) Pl. 33, figs. 4a-c

Globigerina topilensis Cushman, 1925, Contr. Cushman Lab. Foram. Res., vol. 1, p. 7, pl. 1, figs. 9a-c; Howe, 1939, Louisiana Dept. Cons., Geol., Bull. 14, p. 84, pl. 12, figs. 1-3.

Truncorotaloides topilensis Loeblich, Tappan, and Bolli, 1957, U. S. Nat. Mus., Bull. 215, p. 170, pl. 39, figs. 13-16b.

Test small, plano-convex, dorsal side flattened except for the last chamber, ventral side inflated, consisting of two whorls in a low trochospiral arrangement; chambers 10 in number, four in the last whorl, loosely appressed, top-shaped, enlarging rapidly in size; sutures distinct, depressed on the dorsal side, more strongly depressed ventrally; wall hyaline, prominently hispid; aperture umbilical to extraumbilical, a low elongate arch with a faint lip, with small secondary sutural apertures on the dorsal side. Height, 0.33 mm.; width, 0.27 mm.; thicknuess, 0.25 mm.

Common. Castle Hayne formation, at Natural Well.

This species occurs throughout the formation with only slight variation. The forms range from 0.25 mm.—0.33 mm. in height. In some of the smaller specimens the secondary apertures are absent, and the chambers are somewhat globular in shape. No sinistrally coiled specimens were found. The specimens from Natural Well are similar to the type figure and to those reported by Howe from the Cook Mountain formation of Louisiana.

Bolli (1957, p. 170) placed this species in the genus *Truncorotaloides,* but the Castle Hayne species differ from those figured by Bolli in having more closely appressed chambers, less hispid tests, and smaller secondary apertures. The Castle Hayne species are similar to the type figure and type description except for the secondary apertures and so are here assigned to the genus *Globigerinoides*.

Plesiotype.—U.N.C. Cat. No. 3410.

Genus **ORBULINA** d'Orbigny, 1839

Orbulina sp. cf. **O. universa** d'Orbigny Pl. 34, fig. 1

Orbulina universa d'Orbigny, 1839, Foraminifères, in de la Sagra, Histoire, physique, politique et naturelle de l'ile de Cuba, p. 2, vol. 8, pl. 1, fig. 1; Loeblich, Tappan, and Bolli, 1957, U. S. Nat. Mus., Bull. 215, p. 35, pl. 7, fig. 3.

Test spherical, composed of a single chamber; wall hyaline, finely perforate, with no ornamentation; aperture not visible. Diameter, 0.30 mm.

Abundant. Castle Hayne formation, at Natural Well.

Specimens from Natural Well are poorly preserved and any early globigerinid structures, which may have been present, are not preserved. Details of the pores on the surface of the tests are absent due to recrystallization, but the test walls seem to be finely perforate. The specimens are found throughout the formation and range from 0.18 mm.—0.39 mm. in diameter. A few have been compressed and are subspherical in shape.

Plesiotype.—U.N.C. Cat. No. 3432.

Family **HETEROHELICIDAE** Cushman, 1927

Genus **BOLIVINA** d'Orbigny, 1839

Bolivina marginata multicostata Cushman Pl. 43, figs. 1a-b

Bolivina aenariensis (Costa) var. *multicostata* Cushman, 1918, U. S. Geol. Sur., Bull. 676, p. 48, pl. 10, fig. 2.

Bolivina marginata Cushman var. *multicostata* Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 46, pl. 8, figs. 13, 14; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 25, pl. 8, figs. 10a, 10b; Cushman, 1937, Cushman Lab. Foram. Res., Spec. Pub. 9, p. 87, pl. 10, figs. 7-10; Puri, 1953, Florida Geol. Sur., Bull. 36, p. 121, pl. 22, figs. 3-6.

Test elongate, compressed, tapering gradually from the apertural to the initial end, keeled throughout, ornamented with prominent costae of varying lengths; chambers numerous, 11 pairs compose the test, indistinct in early portion, inflated slightly in later portion; sutures slightly depressed, curving toward the periphery; wall hyaline, medium perforate; aperture elongate, narrow. Length, 0.48 mm.; width, 0.22 mm.; thickness, 0.11 mm.

Rare. Duplin marl, at Natural Well and Barwick farm.

Duplin marl specimens range from 0.28 mm.—0.48 mm. in length and are smaller, more regular in outline, and have shorter costae than the type figure.

Plesiotype.—U.N.C. Cat. No. 3454.

Bolivina paula Cushman and Cahill Pl. 43, figs. 2a-b

Bolivina paula Cushman and Cahill in Cushman and Ponton, 1932, Florida Geol. Sur., Bull. 9, p. 84, pl. 12, figs. 6a, 6b; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 26, pl. 8, figs. 14a, 14b; Cushman, 1937, Cushman Lab. Foram. Res., Spec. Pub. 9, p. 91, pl. 11, figs. 9a, 9b.

Test minute, compressed, periphery subacute in apertural view, sides slightly tapering from the apertural to the initial end; chambers numerous, a total of nine pairs, increasing gradually in height as added; sutures slightly depressed, curving obliquely down toward the periphery; aperture a high arch on the median line of the apertural face. Length, 0.25 mm.; width, 0.11 mm.; thickness, 0.06 mm.

Rare. Duplin marl, at Natural Well and Barwick farm.

Duplin marl specimens range in length from 0.22 mm.—0.27 mm. and are smaller but otherwise similar to the type figure.

Plesiotype.—U.N.C. Cat. No. 3455.

Genus **LOXOSTOMUM** Ehrenberg, 1854

Loxostomum distoloculatum, new species Pl. 43, figs. 3a-b

Test elongate, compressed, sides nearly parallel throughout its length, tapering slightly towards the initial end, periphery subacute with a narrow keel; chambers flattened, loosely appressed, five pairs compose the test, early chambers planispirally coiled, ultimate chamber enlarged; sutures curving sharply in the middle of the test, more gently curving toward the periphery, composed of clear shell material, flush with the surface; wall hyaline, finely perforate; aperture terminal, an elongate slit. Length, 0.51 mm.; width, 0.23 mm.; thickness, 0.13 mm.

Rare. Duplin marl, at Natural Well and Barwick farm.

The specimens vary from 0.40 mm.—0.65 mm. in length and from 0.18 mm.—0.24 mm. in width with no appreciable variation in thickness. The last few chambers in one specimen are slightly twisted and in two specimens the chambers are slightly more closely appressed. Chambers vary in number from five—seven pairs.

Loxostomum distoloculatum may be readily distinguished from *L. truncatum* Finlay (1947, New Zealand Jour. Sci. Technology, vol. 28, p. 280, pl. 6, figs. 91-96) by the greatly enlarged terminal chamber, smaller size, fewer chambers, loosely appressed chambers, and downwardly curving sutures near the periphery.

Holotype.—U.N.C. Cat. No. 3498.

Family **BULIMINIDAE** Jones, 1876

Genus **REUSSELLA** Galloway, 1933

Reussella spinulosa (Reuss) Pl. 43, figs. 4a-b

Verneuilina spinulosa Reuss, 1850, Denkschr. Akad. Wiss. Wien, vol. 1, p. 374, pl. 47, fig. 12.

Reussia spinulosa Cushman and Kellet, 1929, U. S. Nat. Mus., Proc., vol. 75, art. 25, p. 9, pl. 3, figs. 10a, 10b; Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 48, pl. 8, figs. 17a, 17b; Cushman and Ponton, 1932, *ibid.*, Bull. 9, p. 84, pl. 12, figs. 14-16; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 27, pl. 9, figs. 1a, 1b.

Reussella spinulosa Galloway, 1933, Manual of Foraminifera, Principia Press, p. 360, pl. 33, fig. 4; Puri, 1953, Florida Geol. Sur., Bull. 36, p. 123.

Test three-sided, triangular in apertural view, sides slightly concave, angles of chambers and initial end spinose; chambers triserial, five rows composing the test; sutures flush with the surface of the test, distinct, slightly curved and oblique; wall hyaline, finely perforate; aperture damaged but probably an elongate slit in the apertural face. Length, 0.39 mm.; width, 0.25 mm.

Rare. Duplin marl, at Barwick farm only.

Plesiotype.—U.N.C. Cat. No. 3499.

Genus **VIRGULINA** d'Orbigny, 1826

Virgulina sp. cf. **V. dibollensis** Cushman and Applin Pl. 34, figs. 2a-b

Virgulina dibollensis Cushman and Applin, 1926, Amer. Assoc. Pet. Geol., Bull., vol. 10, p. 168, pl. 7, fig. 7a-c; Cushman, 1932, Contr. Cushman Lab. Foram. Res., vol. 8, p. 21, pl. 3, fig. 14; Cushman, 1935, U. S. Geol. Sur., Prof. Paper 181, p. 36, pl. 14, figs. 1-3; Cushman and Herrick, 1945, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 3, p. 65, pl. 10, fig. 19; Cushman, 1946, Cushman Lab. Foram. Res., Spec. Pub. 16, p. 26, pl. 5, fig. 6; Bandy, 1949, Bull. Amer. Paleont., vol. 32, No. 131, p. 136, pl. 26, figs 9a, 9b.

Test elongate, wide at the apertural end tapering to the subacute initial end, periphery broadly rounded, lobulate; chambers few in number, inflated, about six pairs compose the test, increasing rapidly in size as added, loosely appressed; sutures distinct, depressed, slightly curved; wall hyaline, finely perforate; aperture elongate, narrow. Length, 0.44 mm.; width, 0.20 mm.; thickness, 0.15 mm.

Rare. Castle Hayne formation, at Natural Well.

The one specimen found at Natural Well differs from the type figure in the lobulate periphery, inflated chambers, and the wider, thicker test. It may be a distinct species, but insufficient numbers are available to allow naming it. It is somewhat similar to *V. dibollensis* Cushman (1935, pl. 14, fig. 3) but differs in the higher, more inflated chambers, more lobulate periphery and nontwisted early portion.

Plesiotype.—U.N.C. Cat. No. 3452.

Genus **BULIMINELLA** Cushman, 1911

Buliminella elegantissima (d'Orbigny) Pl. 43, figs. 5a-b

Bulimina elegantissima d'Orbigny, 1839, Voyage dans l'Amérique méridionale, vol. 5, pt. 5, Foraminifères, p. 51, pl. 7, figs. 13, 14; Schlumberger, 1882, Feuille Jeunes Naturalistes, vol. 12, p. 28, pl. 1, fig. 14; Brady, 1884, *Challenger* Rept., Zoology, vol. 9, p. 402, pl. 50, figs. 20-22; Sidebottom, 1905, Manchester Lit. Philos. Soc. Mem. and Proc., vol. 49, No. 5, p. 11, pl. 2, fig. 6.

Buliminella elegantissima Cushman, 1911, U. S. Nat. Mus., Bull. 71, pt. 2, p. 89; Cushman, 1925, Contr. Cushman Lab. Foram. Res., vol. 1, p. 40, pl. 6, figs. 5a, 5b; Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 42, pl. 8, figs. 2, 3; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 23, pl. 7, figs. 13, 14; Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Pub. 25, p. 185, pl. 12, fig. 13.

Test elongate, spiral, making about three volutions, initial end tapering; chambers slightly inflated, numerous, eight in the last whorl; sutures distinct, curved, slightly depressed; wall hyaline, smooth, finely perforate; aperture elongate, in a broad depression on the septal face, becoming wider near the middle of the apertural face. Length, 0.36 mm.; width, 0.15 mm.

Common. Duplin marl, at Natural Well and Barwick farm.

Dextral and sinistrally coiled forms occur at both localities.

Plesiotype.—U.N.C. Cat. No. 3456.

Family **CASSIDULINIDAE** d'Orbigny, 1839

Genus **CASSIDULINA** d'Orbigny, 1826

Cassidulina crassa d'Orbigny Pl. 43, figs. 6a-c

Cassidulina crassa d'Orbigny, 1839, Voyage dans l'Amérique méridionale, vol. 5, pt. 5, Foraminifères, p. 56, pl. 7, figs. 18-20; Cushman, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 124, pl. 26, fig. 7; Cushman, 1929, Contr. Cushman Lab. Foram. Res., vol. 5, p. 100, pl. 14, figs. 10a, 10b; Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 58, pl. 11, figs. 6a, 6b; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 33, pl. 12, figs. 2a-c; Puri, 1953, Florida Geol. Sur., Bull. 36, p. 127, pl. 23, figs. 3, 4.

Test small, subcircular in outline, biconvex, periphery broadly rounded; chambers few, inflated; sutures distinct, slightly depressed, radial; wall hyaline, finely perforate; aperture elongate, narrow. Height, 0.24 mm.; width, 0.20 mm.; thickness, 0.12 mm.

Rare. Duplin marl, at Natural Well and Barwick farm.

Cassidulina crassa d'Orbigny, as figured in this paper and in the papers listed above in the synonomy, are conspecific but vary from the type, especially in their small size, being only one-fourth the size of the type.

Plesiotype.—U.N.C. Cat. No. 3458.

Family **UVIGERINIDAE** Galloway and Wissler, 1927

Genus **SIPHONODOSARIA** Silvestri, 1924

Siphonodosaria nuttalli gracillima (Cushman and Jarvis) Pl. 34, fig. 3

Ellipsonodosaria nuttalli gracillima Cushman and Jarvis, 1934, Contr. Cushman Lab. Foram. Res., vol. 10, p. 72, pl. 10, fig. 7; Cushman and Stainforth, 1945, Cushman Lab. Foram. Res., Spec. Pub. 14, p. 56, pl. 9, figs. 14, 15; Cushman and Todd, 1945, *ibid.*, Special Pub. 15, p. 55, pl. 8, fig. 13.

Ellipsonodosaria sp. Cushman, 1948, Maryland Dept. Geol., Mines, Water Res., Bull. 2, p. 239, pl. 19, fig. 11.

Siphonodosaria nuttalli gracillima Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Pub. 25, p. 226, pl. 14, figs. 22, 23.

Test elongate, slightly curved, tapering, periphery lobulate; chambers six in number, widely separated from each other, higher than wide; sutures composed of clear shell material; wall hyaline, finely perforate; aperture terminal, round, on the end of a short, frilled neck. Previous apertures are visible between the chambers. Length, 0.57 mm.; width, 0.08 mm.

Rare. Castle Hayne formation, at Natural Well.

Specimens from the Castle Hayne formation resemble the type figure but differ in the absence of an apical spine, apertural tooth, and smaller size. A broken spine base does appear apically and the absence of the tooth is probably due to leaching. There is variation in the Castle Hayne specimens in the degree of appression of the chambers and the length of the neck. One of the specimens has more closely appressed chambers than the plesiotype and two have shorter necks.

Plesiotype.—U.N.C. Cat. No. 3443.

Genus **ANGULOGERINA** Cushman, 1927

Angulogerina occidentalis (Cushman) Pl. 43, figs. 7a-b

Uvigerina angulosa Cushman, 1922 (not Williamson), Carnegie Inst. Washington, Pub. 311, p. 34, pl. 5, figs. 3, 4.
Uvigerina occidentalis Cushman, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 169.
Angulogerina occidentalis Cushman, 1930, Florida Geol. Sur., Bull. 4, p. 50, pl. 9, figs. 8, 9; Cushman, 1932, Contr. Cushman Lab. Foram. Res., vol. 8, p. 46, pl. 6, figs. 15, 16; Cushman and Cahill, 1933, U. S. Geol. Sur., Prof. Paper 175-A, p. 28, pl. 9, figs. 8a, 8b; Puri, 1953, Florida Geol. Sur., Bull. 36, p. 125, pl. 22, figs. 7, 8.

Test small, elongate, triangular in apertural view with lobulate periphery; chambers distinct, inflated, increasing rapidly in size, all but the last chamber ornamented with prominent costae; sutures distinct, depressed; wall hyaline; aperture terminal, round, at the end of a short neck, with phialine lip. Length, 0.39 mm.; width, 0.18 mm.

Common. Duplin marl, at Natural Well and Barwick farm.

Plesiotype.—U.N.C. Cat. No. 3453.

Angulogerina parvaspinata, new species Pl. 34, figs. 4a-b

Test minute, stout, triangular in apertural view; chambers distinct, loosely appressed, slightly inflated, increasing rapidly in size, a few of the early chambers ornamented with fine, indistinct costae and spines, later chambers spinose, without costae; sutures slightly depressed; aperture terminal, round at the end of a short neck, with phialine lip. Length, 0.29 mm.; width, 0.16 mm.

Common. Castle Hayne formation, at Natural Well.

The species ranges from 0.28 mm.—0.36 mm. in length and from 0.15 mm.—0.17 mm. in width and occurs throughout the formation. A few specimens are slightly more elongate and narrow than the holotype with slightly less chamber inflation in the last few chambers.

The species may be readily distinguished from *A. inflata* Hussey (1949, Jour. Paleont., vol. 23, p. 133, pl. 27, fig. 2) by the narrower test, less inflated, more loosely appressed chambers, and fine costae on the early chambers. *Angulogerina parvaspinata* differs from *A. agrestis* Todd (1948, Univ. Southern California Pub., Allan Hancock Pacific Exped., vol. 6, p. 288, pl. 36, fig. 6) in the stout appearance of the test, smaller size, delicate costae restricted to the early portion, and more delicate spines.

Holotype.—U.N.C. Cat. No. 3395.

Family **PLEUROSTOMELLIDAE** Reuss, 1860

Genus **ELLIPSONODOSARIA** A. Silvestri, 1900

Ellipsonodosaria silesica Jedlitschka Pl. 34, fig. 5

Ellipsonodosaria silesica Jedlitschka, 1930, Naturwiss. Ver. Troppau (C.S.R.), Bd. 36, Nr. 21-22, p. 33, 40, text-figs., 1a-c.

Test elongate, slightly curved, gently tapering, periphery slightly lobulate, initial end rounded, large, elongate; chambers six in number, slightly inflated, closely appressed; sutures indistinct, slightly oblique, flush with the surface in the early portion becoming slightly depressed; wall hyaline, finely perforate; aperture produced, terminal, eccentric, a narrow crescentic slit. Length, 0.68 mm.; width, 0.13 mm.

Rare. Castle Hayne formation at Natural Well.

The single specimen found differs from the type figure in the smaller size, fewer chambers, straighter test, and large elongate initial end. The test has been recrystallized which probably accounts for the indistinct sutures. Observations from the literature indicate that both curvilinear and rectilinear species are included in the genus *Ellipsonodosaria*, though the type species is rectilinear.

Plesiotype.—U.N.C. Cat. No. 3405.

NEW SPECIES FROM THE CASTLE HAYNE FORMATION

Angulogerina parvaspinata Pl. 34, figs. 4a-b
Named for the numerous small spines scattered about the test.

Astacolus magnoliaensis Pl. 24, figs. 1a-b
Named for the Natural Well locality near Magnolia, North Carolina.

Cancris involutus Pl. 30, figs. 1a-c
Named for the involute character of the dorsal and ventral sides of the test.

Cibicides praecipuus Pl. 32, figs. 2a-c
Latin *praecipuus* meaning peculiar, special, extraordinary. Named for the unusual appearance of the species.

Cibicidina minuta Pl. 31, figs. 4a-c
Named for the small test size.

Lagena altahumerifera Pl. 25, figs. 1a-b
Named for the shoulder located high on the test.
Lagena multicostata Pl. 25, figs. 4a-b
Named for the numerous costae which are characteristic of the species.
Lagena torsicostata Pl. 26, figs. 1a-b
Named for the twisted costae which are characteristic of the species.
Nodosaria magnoliaensis Pl. 24, figs. 8a-b
Named for the Natural Well locality, near Magnolia, North Carolina.
Raphanulina subglobosa Pl. 28, figs. 2a-c
Named for the nearly globose shape of the test.
Siphotextularia breviforma Pl. 23, figs. 4a-b
Named for its short, stout character.
Spiroplectammina angulomarginata Pl. 23, figs. 2a-b
Named for the sharply angled margin characteristic of the species.
Textularia concisa Pl. 23, figs. 5a-b
Latin *concisus*, meaning brief, short. Named for the concise, short appearance of the test.

NEW SPECIES FROM THE DUPLIN MARL

Cibicides duplinensis Pl. 40, figs. 3a-c
This species is especially characteristic of the Duplin marl.
Cibicides eccentricus Pl. 40, figs. 4a-c
Latin *eccentricus*, meaning different, odd. Named for the strikingly odd appearance of the test.
Discorbis duplinensis Pl. 39, figs. 2a-c
This species is especially characteristic of the Duplin marl.
Elphidium compressulum Pl. 37, figs. 3a-b
Named for the compressed appearance of the test.
Elphidium limatulum Pl. 37, figs. 5a-b
Latin *limatulus*, meaning filed, polished, smoothed. Named for the glossy, polished appearance of the species.
Globigerina macrastoma Pl. 41, figs. 5a-c
Greek *makros*, long plus *stoma*, mouth. Named for the long, open aperture.
Globigerinoides cancellata Pl. 42, figs. 3a-c
Named for the cancellate appearance of the test.
Loxostomum distoloculatum Pl. 43, figs. 3a-b
Named for the widely separated chambers.
Planorbulinella perforata Pl. 41, figs. 1a-b
Named for the coarsely perforate chambers.
Textularia megaloculata Pl. 35, figs. 1a-b
Named for the unusually large terminal chambers in relation to the earlier chambers.

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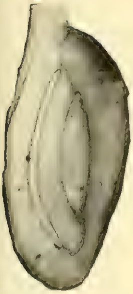
PLATES

Explanation of Plate 23

Castle Hayne Foraminifera from Natural Well

Figure		Page
1.	**Quinqueloculina mauricensis apertaexpansa** Bandy a. Side view. b. Apertural view. c. Opposite side; × 90	231
2.	**Spiroplectammina angulomarginata,** n. sp. a. Apertural view. b. Side view; × 90	232
3.	**Spiroplectammina natchitochensis** Howe a. Side view. b. Apertural view; × 90	234
4.	**Siphotextularia breviforma,** n. sp. a. Side view. b. Apertural view; × 90	234
5.	**Textularia concisa,** n. sp. a. Side view. b. Apertural view; × 90	235
6.	**Textularia eyrei** Finlay a. Side view. b. Apertural view, × 60	236



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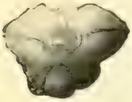

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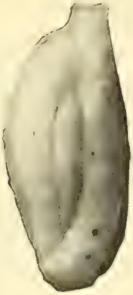

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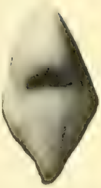

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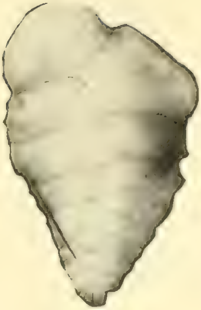

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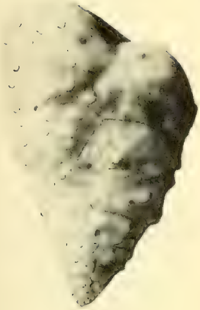

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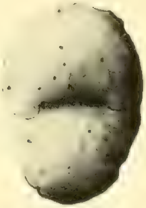

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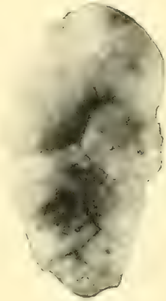

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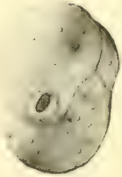

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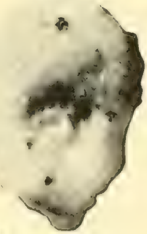

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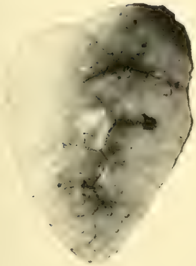

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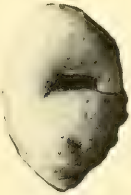

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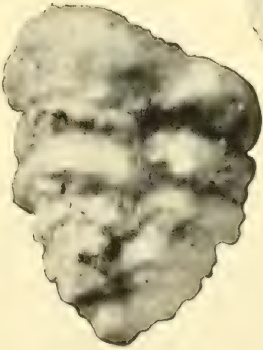

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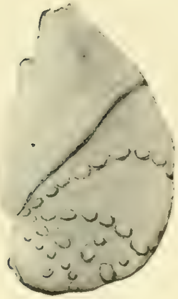
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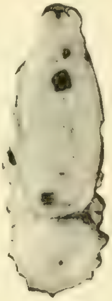
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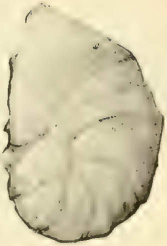
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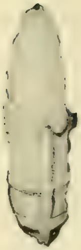
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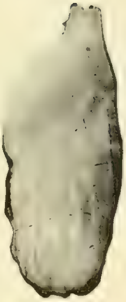
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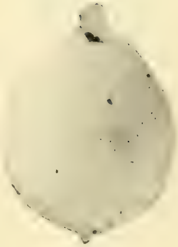
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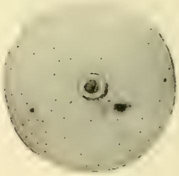
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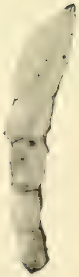
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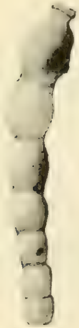
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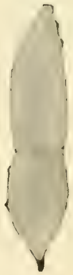
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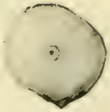

8b

Explanation of Plate 24

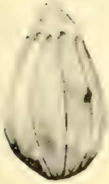
Castle Hayne Foraminifera from Natural Well

Figure	Page
1. **Astacolus magnoliaensis,** n. sp. a. Side view. b. Edge view; × 90	238
2. **Planularia** sp. cf. **P. georgiana** Cushman and Herrick a. Side view. b. Edge view; × 90	239
3. **Marginulina moodysensis** Cushman and Todd Side view; × 60	240
4. **Marginulina winniana** Howe Side view; × 90	240
5. **Oolina morsei** (Kline) a. Side view. b. Top view; × 90	241
6. **Dentalina budensis** Hantken Side view; × 60.	241
7. **Dentalina jacksonensis** (Cushman and Applin) Side view; × 60	242
8. **Nodosaria magnoliaensis,** n. sp. a. Side view. b. Apertural view; × 60	243

Explanation of Plate 25

Castle Hayne Foraminifera from Natural Well

Figure		Page
1.	**Lagena altahumerifera,** n. sp. a. Side view. b. Apertural view; × 90	243
2.	**Lagena fenestrissima** Howe and Ellis a. Side view. b. Apertural view; × 90	244
3.	**Lagena laevis** (Montagu) a. Side view. b. Apertural view; × 90	244
4.	**Lagena multicostata,** n. sp. a. Side view. b. Apertural view; × 90	245
5.	**Lagena ouachitaensis** Howe and Wallace Side view; × 90	246
6.	**Lagena sulcata laevicostata** Cushman and Gray a. Side view. b. Apertural view; × 90	246
7.	**Lagena sulcata spirata** Bandy a. Side view. b. Apertural view; × 90	246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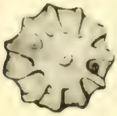
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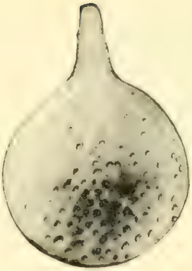
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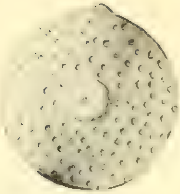
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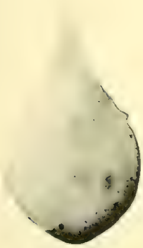
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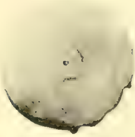
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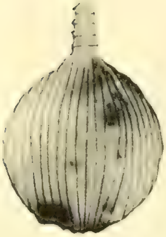
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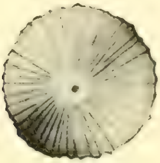
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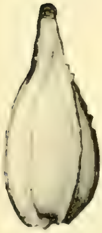
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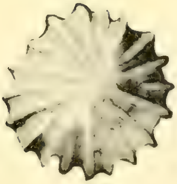
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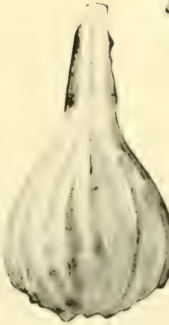
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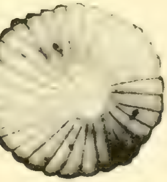
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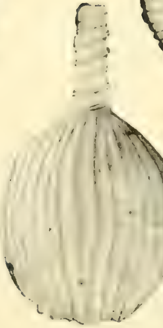
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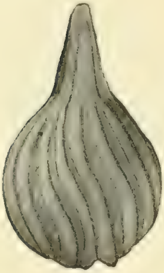
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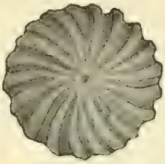
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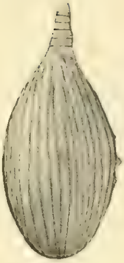
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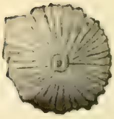
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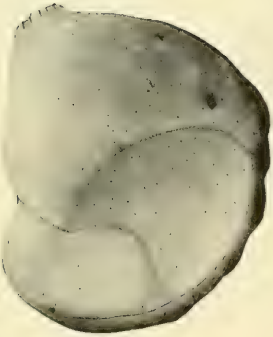
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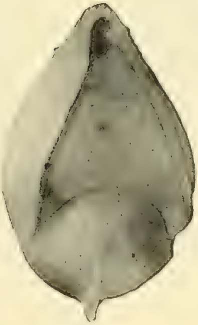
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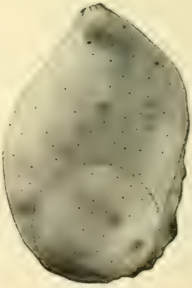
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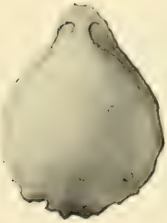
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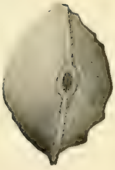
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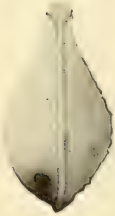
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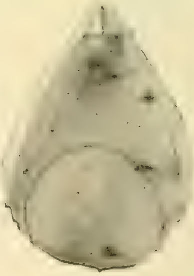
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Explanation of Plate 26

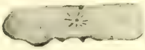
Castle Hayne Foraminifera from Natural Well

Figure		Page
1.	**Lagena torsicostata,** n. sp. a. Side view. b. Apertural view; × 90	247
2.	**Lagena wallacei** Bandy a. Side view. b. Apertural view; × 90	247
3.	**Robulus deformis** (Reuss) a. Side view. b. Edge view; × 90	248
4.	**Robulus ovalis** (Reuss) a. Side view. b. Edge view; × 90	249
5.	**Fissurina howei** (Cushman and Todd) a. Side view. b. Apertural view. c. Lateral view; × 90	249

Explanation of Plate 27

Castle Hayne Foraminifera from Natural Well

Figure	Page
1. **Polymorphina nuda** Howe and Roberts a. Side view. b. Apertural view; × 90	251
2. **Sigmomorphina pulchra** Todd a. Side view. b. Apertural view; c. Opposite side; × 90	252
3. **Guttulina** sp. a. Side view. b. Apertural view. c. Opposite side; × 90	253
4. **Guttulina communis** (d'Orbigny) a. Side view. b. Apertural view. c. Opposite side; × 90	254



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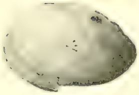

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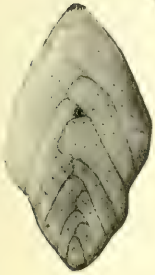

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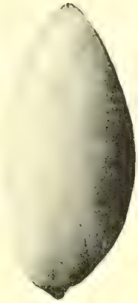

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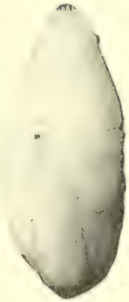

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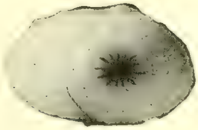

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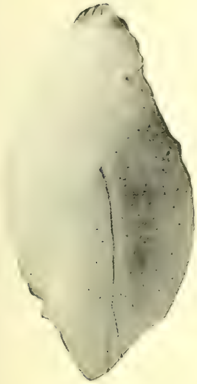

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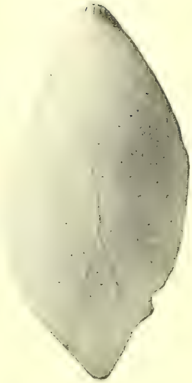

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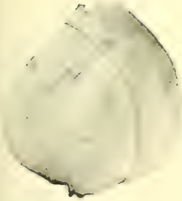

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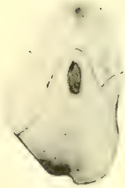

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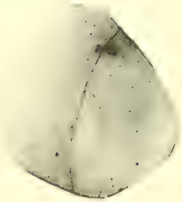

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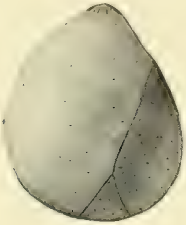
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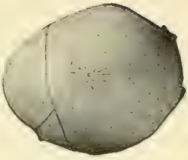
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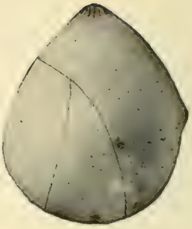
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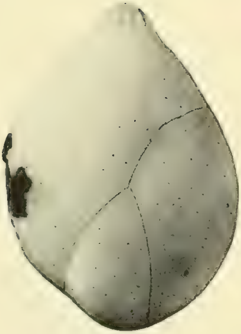
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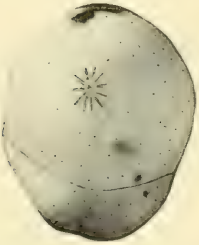
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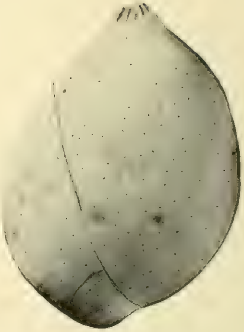
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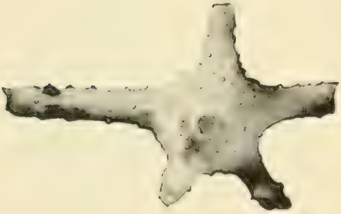
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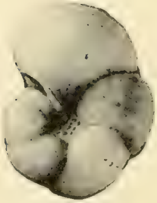
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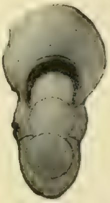

4b

Explanation of Plate 28

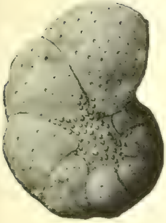
Castle Hayne Foraminifera from Natural Well

Figure		Page
1.	**Raphanulina gibba** (d'Orbigny) a. Side view. b. Apertural view. c. Opposite side; × 90	255
2.	**Raphanulina subglobosa,** n. sp. a. Side view. b. Apertural view. c. Opposite side; × 90	257
3.	**Ramulina globulifera** Brady Side view; × 60	257
4.	**Nonion danvillensis** Howe and Wallace a. Side view. b. Edge view; × 90	258

Explanation of Plate 29

Castle Hayne Foraminifera from Natural Well

Figure	Page
1. **Nonion mauricensis** Howe and Ellis a. Side view. b. Edge view; × 90	259
2. **Nonion planatus** Cushman and Thomas a. Edge view. b. Side view; × 90	260
3. **Nonionella jacksonensis** Cushman a. Dorsal view. b. Edge view. c. Ventral view; × 90	260
4. **Nonionella spissa** Cushman a. Ventral view. b. Edge view. c. Dorsal view; × 90	261
5. **Globorotalia spinulosa** Cushman a. Ventral view. b. Edge view. c. Dorsal view; × 90	265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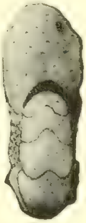
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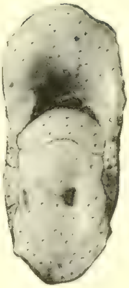
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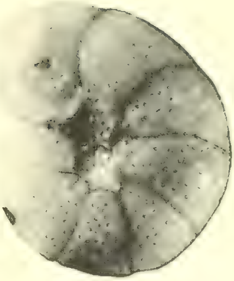
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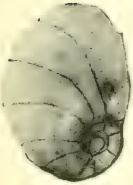
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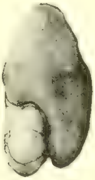
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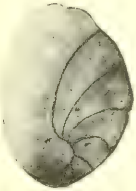
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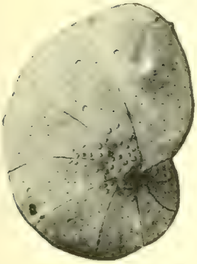
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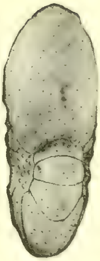
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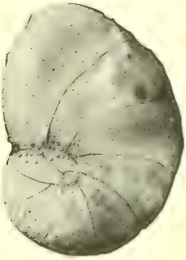
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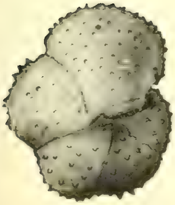
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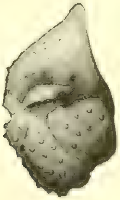
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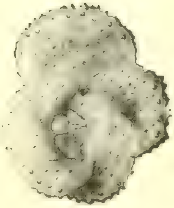
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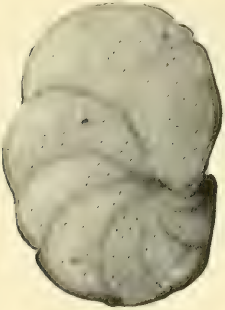
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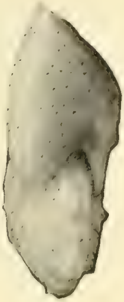
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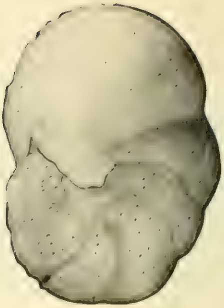
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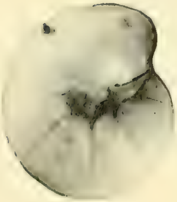
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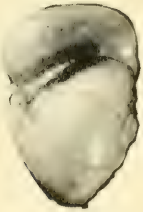
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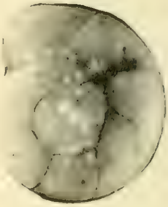
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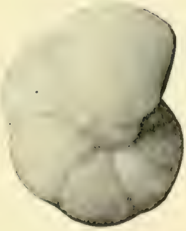
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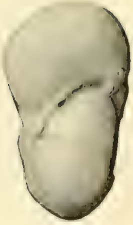
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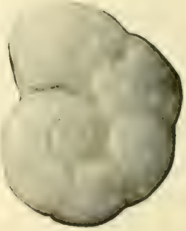
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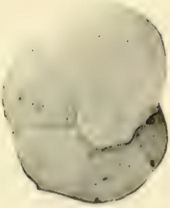
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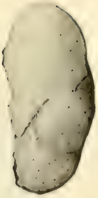
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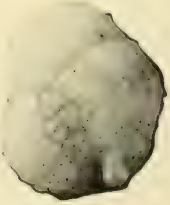
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Explanation of Plate 30

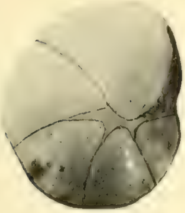
Castle Hayne Foraminifera from Natural Well

Figure		Page
1.	**Cancris involutus,** n. sp. a. Dorsal view. b. Edge view; c. Ventral view; × 90	266
2.	**Valvulineria danvillensis** (Howe and Wallace) a. Ventral view. b. Edge view. c. Dorsal view; × 90	267
3.	**Valvulineria octocamerata** (Cushman and Hanna) a. Ventral view. b. Edge view. c. Dorsal view; × 90	268
4.	**Valvulineria texana** Cushman and Ellisor a. Ventral view. b. Edge view. c. Dorsal view; × 90	268

Explanation of Plate 31

Castle Hayne Foraminifera from Natural Well

Figure	Page
1. **Alabamina mississippiensis** Todd a. Ventral view. b. Edge view. c. Dorsal view; × 90	269
2. **Cibicidina blanpiedi** (Toulmin) a. Dorsal view. b. Edge view. c. Ventral view; aperture reconstructed; × 90	271
3. **Cibicidina cooperensis** (Cushman) a. Ventral view. b. Edge view. c. Dorsal view; × 90	271
4. **Cibicidina minuta,** n. sp. a. Ventral view. b. Edge view. c. Dorsal view; × 90	272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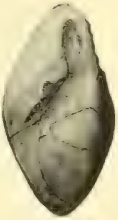
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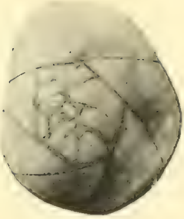
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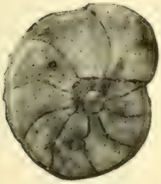
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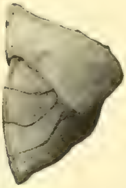
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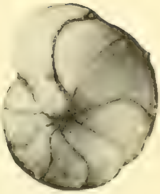
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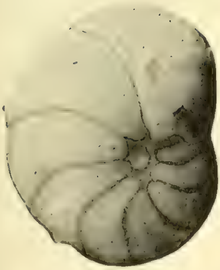
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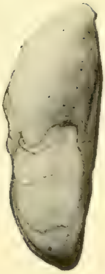
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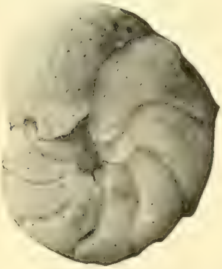
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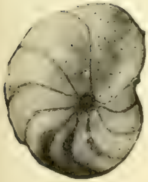
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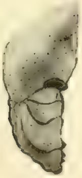
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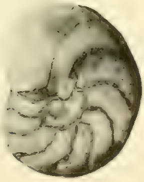
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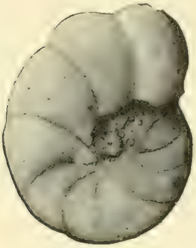
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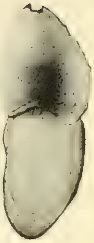
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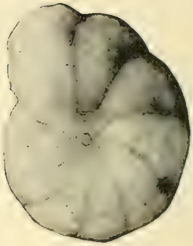
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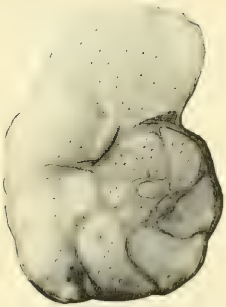
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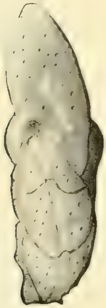
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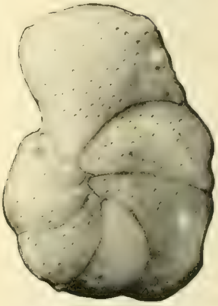
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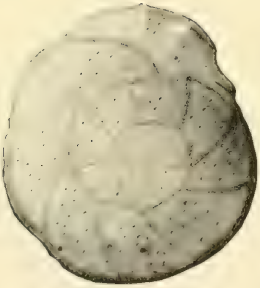
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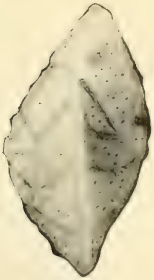
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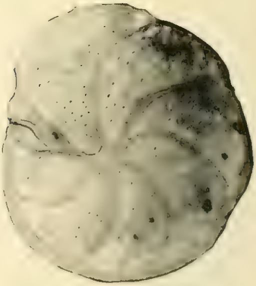
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Explanation of Plate 32

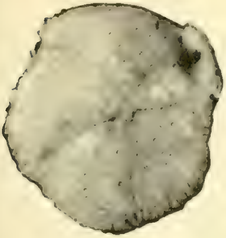
Castle Hayne Foraminifera from Natural Well

Figure		Page
1.	**Anomalina umbonata** Cushman a. Dorsal view. b. Edge view. c. Ventral view; × 90	275
2.	**Cibicides praecipuus,** n. sp. a. Dorsal view. b. Edge view. c. Ventral view; × 90	278
3.	**Eponides cocoaensis** Cushman a. Dorsal view. b. Edge view. c. Ventral view; × 90	279

Explanation of Plate 33

Castle Hayne Foraminifera from Natural Well

Figure		Page
1.	**Siphonina danvillensis** Howe and Wallace a. Ventral view. b. Edge view. c. Dorsal view; × 90	279
2.	**Globigerina bulloides** d'Orbigny a. Ventral view. b. Edge view. c. Dorsal view; × 90	281
3.	**Globigerina triloculinoides** Plummer a. Ventral view. b. Edge view. c. Dorsal view; × 90	283
4.	**Globigerinoides topilensis** (Cushman) a. Ventral view. b. Edge view. c. Dorsal view; × 90	285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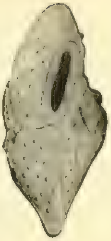
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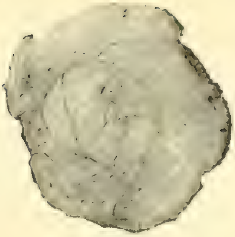
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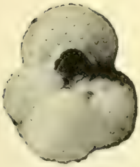
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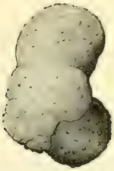
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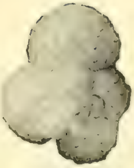
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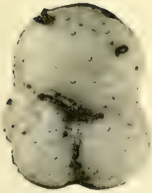
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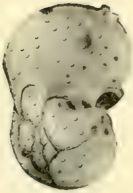
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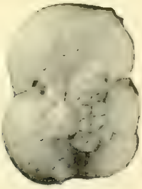
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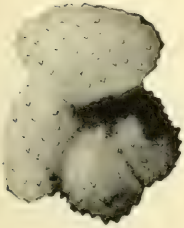
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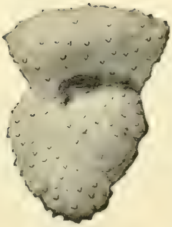
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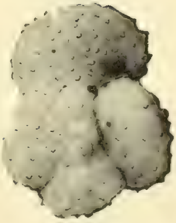
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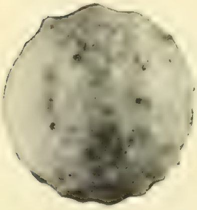

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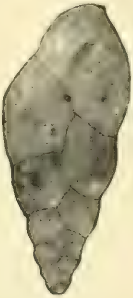

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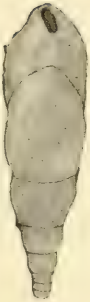

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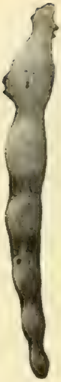

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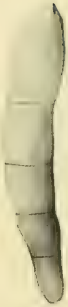

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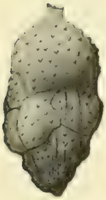

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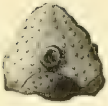

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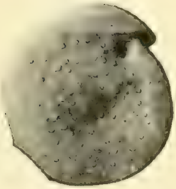

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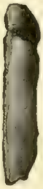

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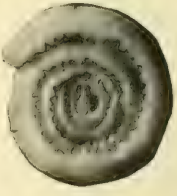

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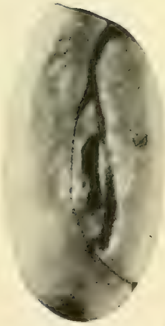

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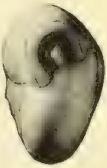

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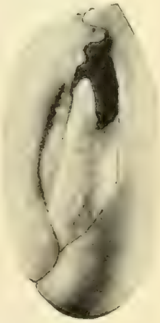

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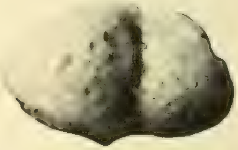

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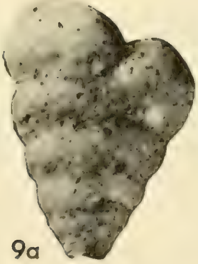

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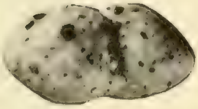

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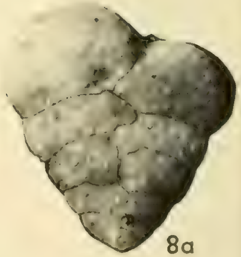

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Explanation of Plate 34

Figs. 1-5—Castle Hayne Foraminifera from Natural Well

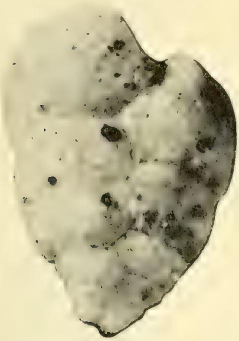
Figs. 6-9—Duplin Foraminifera from Natural Well

Figure		Page
1.	**Orbulina** sp. cf. **O. universa** d'Orbigny Side view; × 90	286
2.	**Virgulina** sp. cf. **V. dibollensis** Cushman and Applin a. Side view. b. Lateral view; × 90	288
3.	**Siphonodosaria nuttalli gracillima** (Cushman and Jarvis) Side view; × 90	290
4.	**Angulogerina parvaspinata,** n. sp. a. Side view. b. Apertural view; × 90	291
5.	**Ellipsonodosaria silesica** Jedlitschka Side view; × 60	292
6.	**Planispirillina orbicularis** (Bagg) a. Ventral side. b. Edge view. c. Dorsal side; × 90	230
7.	**Quinqueloculina seminula** (Linné) a. Side view. b. Apertural view. c. Opposite side; × 90	232
8.	**Textularia cuyleri** Davis a. Side view. b. Apertural view; × 90	235
9.	**Textularia** sp. cf. **T. dollfussi** Lalicker a. Side view. b. Apertural view; × 60	236

Explanation of Plate 35

Duplin Foraminifera from Natural Well

Figure		Page
1.	**Textularia megaloculata,** n. sp. a. Side view. b. Apertural view; × 60	237
2.	**Textularia** sp. a. Side view. b. Apertural view; × 90	238
3.	**Robulus americanus** (Cushman) a. Edge view. b. Side view; × 40	248
4.	**Fissurina orbignyana lacunata** (Burrows and Holland) a. Side view. b. Apertural view; × 90	250
5.	**Pseudopolymorphina rutila** (Cushman) a. Side view. b. Opposite side; × 40	251
6.	**Laryngosigma williamsoni** (Terquem) Side view; × 90	253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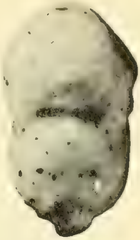
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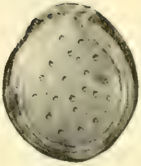
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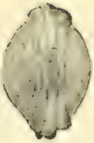
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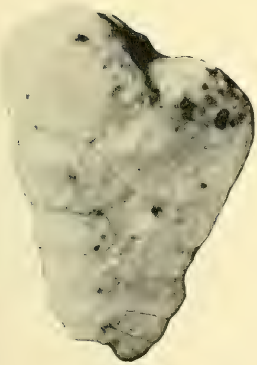
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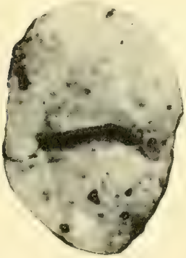
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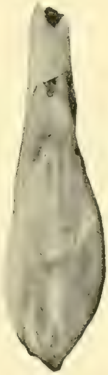
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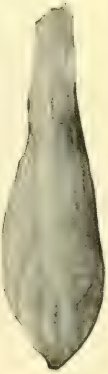
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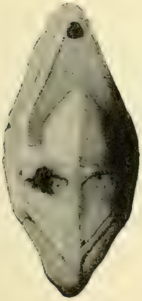
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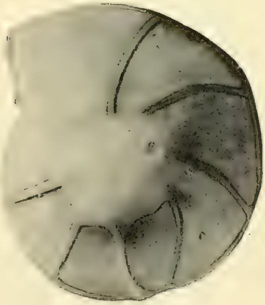
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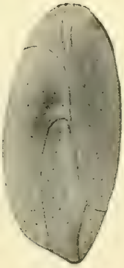
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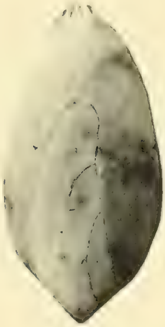

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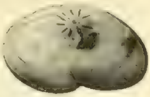

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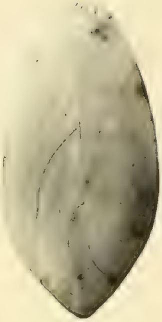

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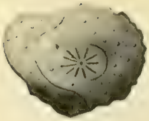

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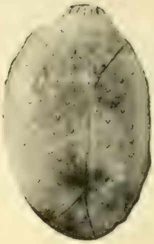

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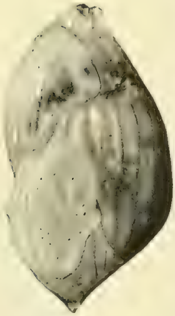

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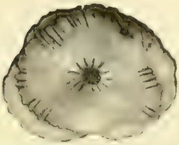

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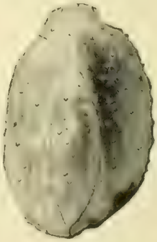

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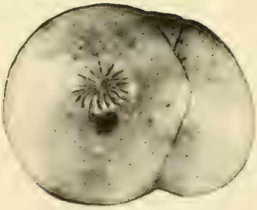

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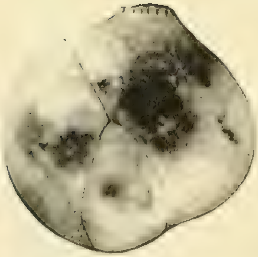

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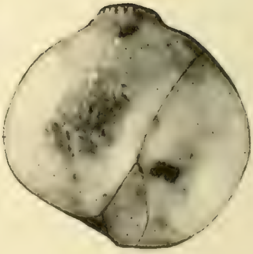

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Explanation of Plate 36

Duplin Foraminifera from Natural Well

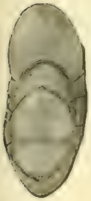
Figure	Page
1. **Sigmomorphina terquemiana** (Fornasini) .... a. Side view. b. Opposite side. c. Apertural view; × 90	252
2. **Guttulina costatula** Galloway and Wissler a. Side view. b. Apertural view; × 90	254
3. **Raphanulina** sp. cf. **R. hispida** (Terquem) a. Side view. b. Opposite side. c. Apertural view; × 90	256
4. **Raphanulina** sp. cf. **R. laeviglobosa** ten Dam .... a. Side view. b. Apertural view. c. Opposite side; × 60	256

Explanation of Plate 37

Figs. 1-4, 6—Duplin Foraminifera from Natural Well

Fig. 5—Duplin Foraminifera from Barwick farm

Figure	Page
1. **Nonion decoratus** Cushman and McGlamery a. Apertural view. b. Side view; × 90	259
2. **Elphidium advena** (Cushman) a. Edge view. b. Side view; × 90	262
3. **Elphidium compressulum,** n. sp. a. Edge view. b. Side view; × 90	262
4. **Elphidium gunteri** Cole a. Side view. b. Edge view; × 90	263
5. **Elphidium limatulum,** n. sp. a. Edge view. b. Side view; × 90	263
6. **Elphidium poeyanum** (d'Orbigny) a. Edge view. b. Side view; × 90	264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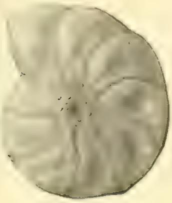
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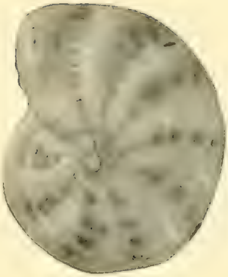
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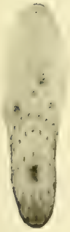
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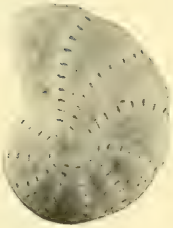
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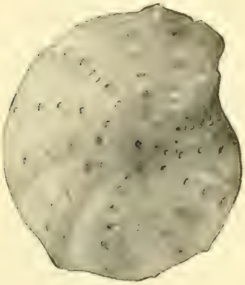
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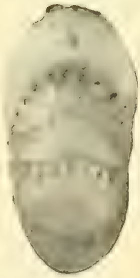
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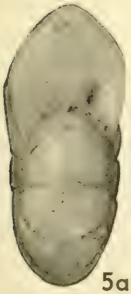
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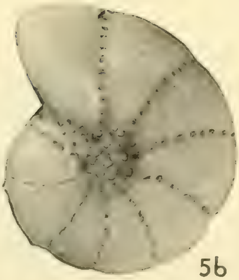
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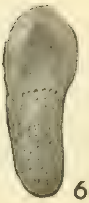
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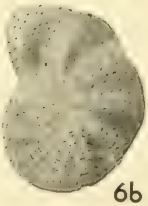
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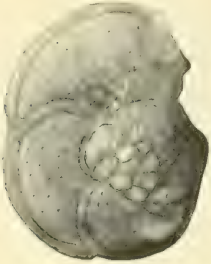
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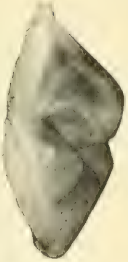
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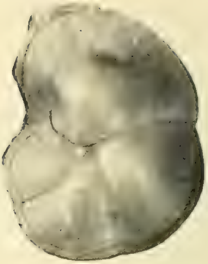
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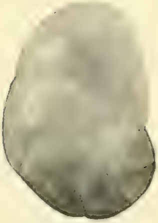
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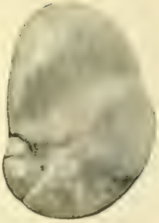
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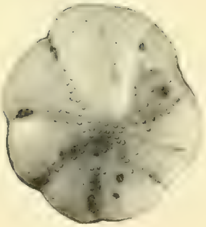
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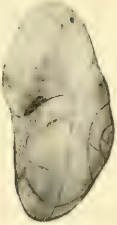
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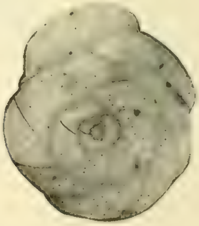
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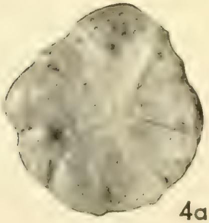
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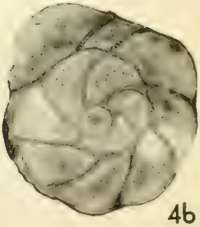
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Explanation of Plate 38

Figs. 1, 2—Duplin Foraminifera from Natural Well

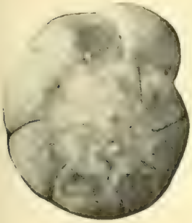
Figs. 3, 4—Duplin Foraminifera from Barwick farm

Figure		Page
1.	**Globorotalia menardii** (d'Orbigny) a. Dorsal view. b. Apertural view. c. Ventral view; × 90	264
2.	**Cancris communis** Cushman and Todd a. Dorsal view. b. Edge view. c. Ventral view; × 90	265
3.	**Buccella depressa** Andersen a. Ventral view. b. Apertural view. c. Dorsal view; described specimen with oblique dorsal sutures; × 90	269
4.	**Buccella depressa** Andersen a. Ventral view. b. Dorsal view; illustrating less oblique dorsal sutures; × 90	269

Explanation of Plate 39

Duplin Foraminifera from Natural Well

Figure		Page
1.	**Streblus beccarii parkinsoniana** (d'Orbigny) a. Dorsal view. b. Edge view. c. Ventral view; × 90	270
2.	**Discorbis duplinensis,** n. sp. a.Ventral view. b. Edge view. c. Dorsal view. Holotype × 90	273
3.	**Discorbis duplinensis,** n. sp. a. Dorsal view. b. Edge view. c. Ventral view. Paratype × 90	273
4.	**Discorbis terquemi** (Rzehak) a. Ventral view. b. Edge view. c. Dorsal view; ×90	273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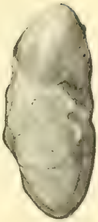
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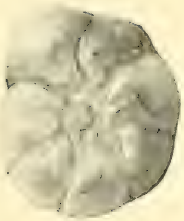
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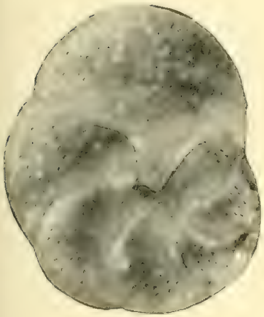
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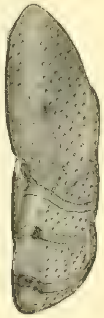
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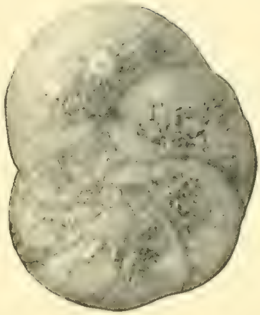
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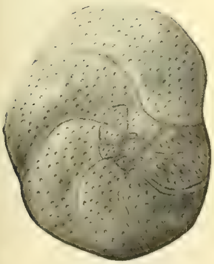
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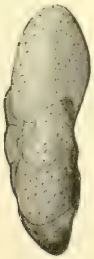
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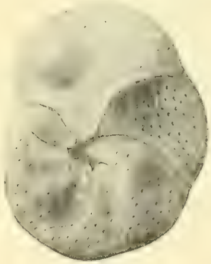
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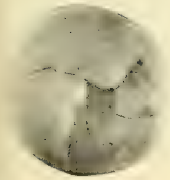
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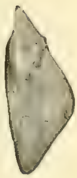
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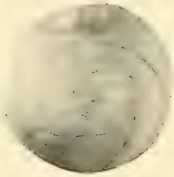
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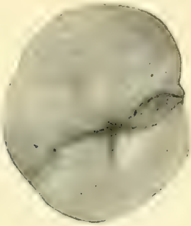
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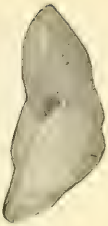
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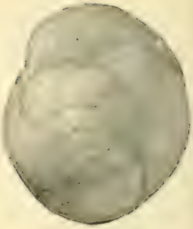
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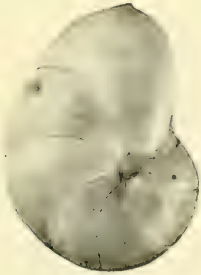
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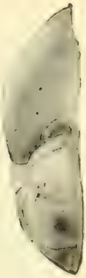
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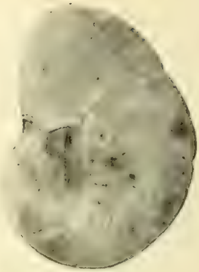
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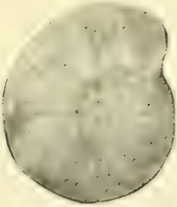
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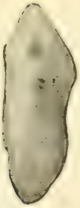
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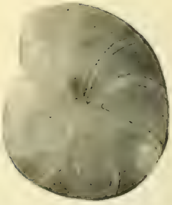
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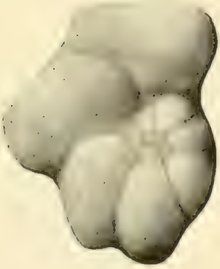
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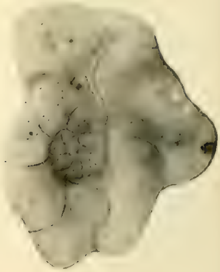
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Explanation of Plate 40

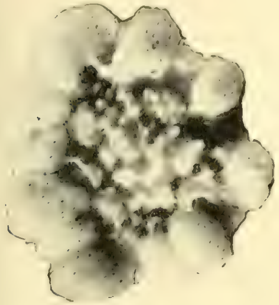
Duplin Foraminifera from Natural Well

Figure		Page
1.	**Discorbis turritus** Cushman a. Ventral view. b. Edge view. c. Dorsal view; × 90	274
2.	**Cibicides americanus** (Cushman) a. Ventral view. b. Apertural view. c. Dorsal view; × 60	275
3.	**Cibicides duplinensis,** n. sp. a. Dorsal view. b. Apertural view. c. Ventral view; × 90	276
4.	**Cibicides eccentricus,** n. sp. a. Ventral view. b. Apertural view. c. Dorsal view; × 60	277

Explanation of Plate 41

Duplin Foraminifera from Natural Well

Figure	Page
1. **Planorbulinella perforata,** n. sp. a. Ventral view. b. Dorsal view. Holotype × 50	280
2. **Planorbulinella perforata,** n. sp. a. Ventral view. b. Dorsal view. Paratype × 60	280
3. **Planorbulinella perforata,** n. sp. a. Ventral view. b. Dorsal view. Paratype × 60	280
4. **Globigerina apertura** Cushman a. Ventral view. b. Edge view. c. Dorsal view; × 90	281
5. **Globigerina macrastoma,** n. sp. a. Dorsal view. b. Edge view. c. Ventral view; × 90	282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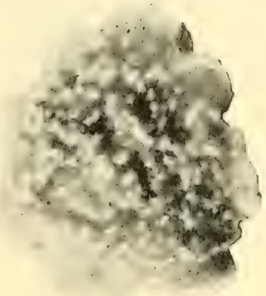
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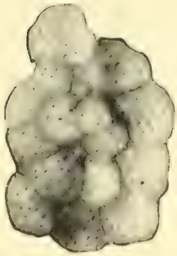
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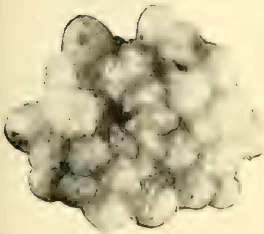
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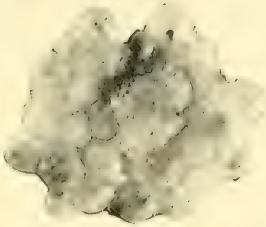
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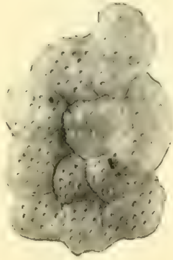
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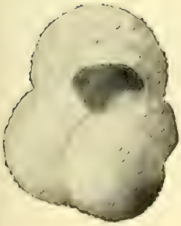
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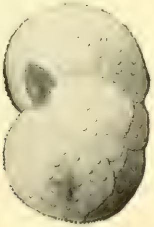
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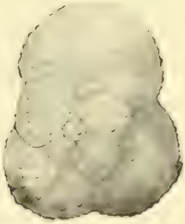
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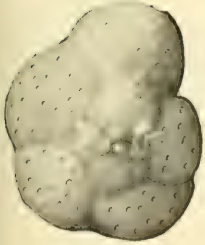
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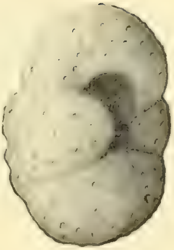
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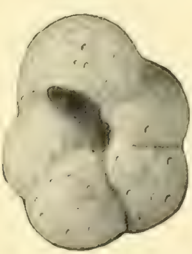
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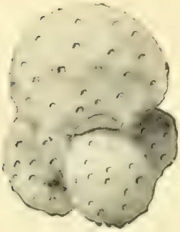
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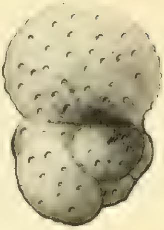
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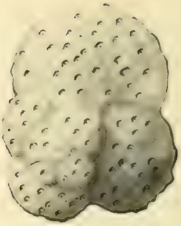
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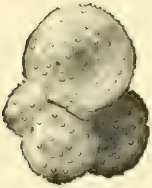
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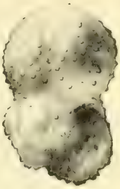
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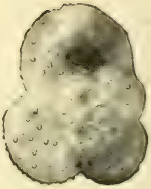
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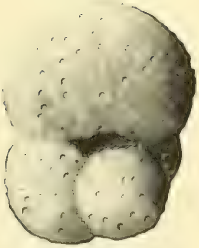
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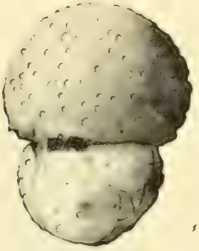
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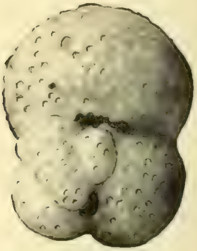
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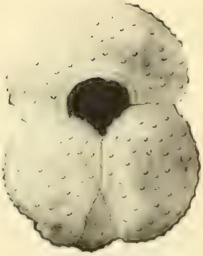
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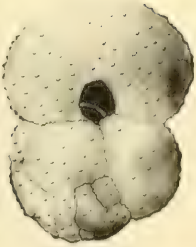
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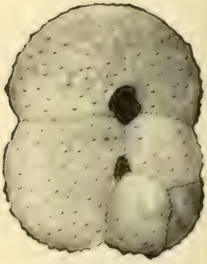
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Explanation of Plate 42

Figs. 1, 2—Duplin Foraminifera from Barwick farm

Figs. 3, 4—Duplin Foraminifera from Natural Well

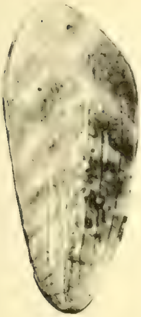
Figure		Page
1.	**Globigerina protoreticulata** Hofker a. Ventral view. b. Edge view. c. Dorsal view; × 90	282
2.	**Globigerina triloculinoides** Plummer a. Ventral view. b. Edge view. c. Dorsal view; × 90	283
3.	**Globigerinoides cancellata,** n. sp. a. Ventral view. b. Edge view. c. Dorsal view; × 90	284
4.	**Globigerinoides rubra** (d'Orbigny) a. Ventral view. b. Edge view. c. Dorsal view; × 90	284

Explanation of Plate 43

Figs. 1, 2, 5-7—Duplin Foraminifera from Natural Well

Figs. 3, 4—Duplin Foraminifera from Barwick farm

Figure		Page
1.	**Bolivina marginata multicostata** Cushman a. Side view. b. Apertural view; × 90	286
2.	**Bolivina paula** Cushman and Cahill a. Side view. b. Apertural view; × 90	287
3.	**Loxostomum distoloculatum,** n. sp. a. Side view. b. Apertural view; × 90	287
4.	**Reussella spinulosa** (Reuss) a. Side view. b. Top view; × 90	288
5.	**Buliminella elegantissima** (d'Orbigny) a. Side view. b. Side view; × 90	289
6.	**Cassidulina crassa** d'Orbigny a. Side view. b. Edge view. c. Side view; × 90	289
7.	**Angulogerina occidentalis** (Cushman) a. Side view. b. Apertural view; × 90	291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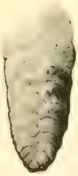
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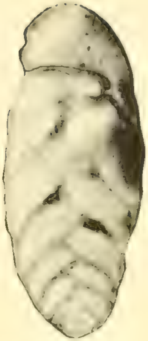
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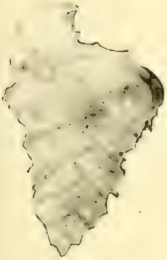
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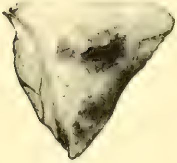
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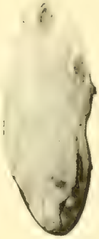
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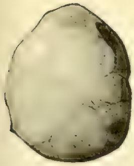
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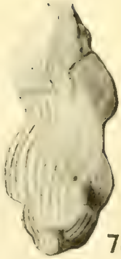
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THE AMMONITE FAUNA OF THE KIALAGVIK FORMATION AT WIDE BAY, ALASKA PENINSULA
PART I. LOWER BAJOCIAN (AALENIAN)

By

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McMaster University, Hamilton, Ontario

August 28, 1964

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THE AMMONITE FAUNA OF THE KIALAGVIK FORMATION AT WIDE BAY, ALASKA PENINSULA
PART I. LOWER BAJOCIAN (AALENIAN)

Gerd E. G. Westermann

McMaster University, Hamilton, Ontario

ABSTRACT

The Kialagvik formation comprises the lowest 300-600 m. of a thick Middle and Upper Jurassic clastic series exposed in the Wide Bay anticline, Alaska Peninsula. Stratigraphy is complicated by lateral lithofacies changes and faulting. The boundary with the overlying Shelikof formation is now placed within the Middle Bajocian and is strongly heterochronous.

The basal 100 m. contains the earliest Bajocian *Tmetoceras scissum* (Ben.). The ca. 300 m. *E. howelli* Zone [*nov.*] contains rich and well-preserved ammonite assemblages typified by *Erycitoides* [*nov.*] *howelli, E. (Kialagvikes)* [*nov.*] *kialagvikensis* [Hammatoceratinae] and *Pseudolioceras mclintocki whiteavesi* [Harpoceratinae] White spp.; it also includes the new *E. profundus, E. teres, E. paucispinosus, E. (K.) spinatus, E. (K.) levis, Erycites imlayi, Abbasites platystomus, Eudmetoceras nucleospinosum, Tmetoceras kirki, T. kirki flexicostatum, T. (Tmetoites)* [*nov.*] *tenue*. New zonules are based on the ranges or acmes of *E. howelli* [Lower *E. howelli* Zone], *E. teres* and *E. profundus* [Middle *E. howelli* Zone], *Eudmetoceras* and *T. tenue* and *T. flexicostatum* [Upper *E. howelli* Zone].

This fauna is endemic to Alaska and northern Yukon. Other forms strongly suggest a late Early Bajocian (late Aalenian) age for all of the *Erycitoides howelli* Zone: *Eudmetoceras* (*Euaptetoceras*) *amplectens* (Buck.) is restricted to the *Graphoceras concavum* and basal *Sonninia sowerbyi* Zones in Europe; *E. eudmetum jaworskii, subsp. nov.* occurs, together with the latter and some species closely related to Alaskan *E. nucleospinosum* and *Tmetoceras,* in the "*Eudmetoceras* beds" of Argentina which directly underlie or are synonymous with the lower "*Sonninia* beds"; *Abbasites* is restricted to the upper *L. murchisonae* and *G. concavum* Zones in Europe. The *E. howelli* Zone is directly overlain by beds containing a rich ammonite assemblage of the *S. sowerbyi* Zone.

Apparent sexual dimorphs hitherto unknown in Hammatoceratinae and Tmetoceratinae are subgenerically distinguished. The first Hammatoceratidae aptychus, *Praestriaptychus antiquus, sp. nov.,* is described.

PREFACE

This is the first part of a study of the extraordinarily rich and well-preserved ammonoid fauna from Wide Bay (formerly Kialagvik Bay) comprising the Lower Bajocian (Aalenian) assemblages from the Kialagvik formation, *i.e.* the *E. howelli* Zone (formerly "*Hammatoceras*" Zone) and underlying beds. A second study will deal with the large assemblage from the overlying early Middle Bajocian beds of the *S. sowerbyi* Zone.

The faunas described herein were collected in the main by geologists of Shell Oil Company (Seattle, Washington) in 1953 and 1955, and also on U.S. Geological Survey field parties undertaken by L. B. Kellum, S. N. Daviess, C. M. Swinney, in 1944 and 1945, and R. W. Imlay and Don J. Miller, in 1948. There was, finally, the original small collection described by White (1889) in the U.S. National Museum, Washington, which was furnished by the Natural Science Establishment in Rochester, New York. The writer is deeply indebted to Mahlon V. Kirk, Shell Oil Company paleontologist who visited Wide Bay in 1953 and 1955, arranged the shipment of the large collection kindly made available to the writer, and furnished indispensable stratigraphical details of the collecting sites. The same gratitude is extended to Dr. R. Imlay for the loan of the U.S. National Museum and Geological Survey fossil material and for valuable information. Topographic plots, litho-stratigraphical correlations and compilations are almost entirely based on information received from both named colleagues. The writer did not visit the area under study.

The intensive field studies of Shell Oil Company have resulted in the reinterpretations of the Kialagvik-Shelikof formations boundary. The writer wishes to thank Shell Oil Company for the pertinent information given to him; much of the evidence on this subject must remain confidential, however.

The writer is further indebted to the following colleagues for the loan of type specimens and furnishing of plastotypes: Drs. H. Küpper, Geologische Bundesanstalt Wien, W. Barthel, Bayrisches Staatsinstitut für Geologie und Paläontologie, München, A. Seilacher, Institut und Museum für Geologie und Paläontologie der Universität Göttingen, H. K. Erben, Geologisch-Paläontologisches Institut der Universität, Bonn, H. Frebold, Geological Survey of Canada, Ottawa, R. W. Imlay and G. A. Cooper, U.S. National Museum, Washington. The writer wants to give thanks for help and guidance received in search for fossil collections in museums and in the field, as well as for the valuable comments and editorial assistance without which the writer's studies in Dorset, Normandy, the Jura Mountains, Provence, the Basel Jura, the Central Apennine, and the Venetian Alps, in summer of 1962, would have been unsuccessful. These are Brigadier Bomford, Drs. F. Lieb, M. Rioult, K. Hoffman, P. L. Maubeuge, M. S. Elmi, Dal Piaz, G. Merla, H. Rieber, and L. Pante. In summer 1963 the writer briefly re-studied the Bajocian sections of the Colpitts group in the Suplee area of east-central Oregon, as described by Lupher (1941).

Financial assistance, received as research and travel grants from the National Research Council of Canada and McMaster University, respectively, is gratefully acknowledged. Financial help was received from McMaster University toward publication.

INTRODUCTION

HISTORY

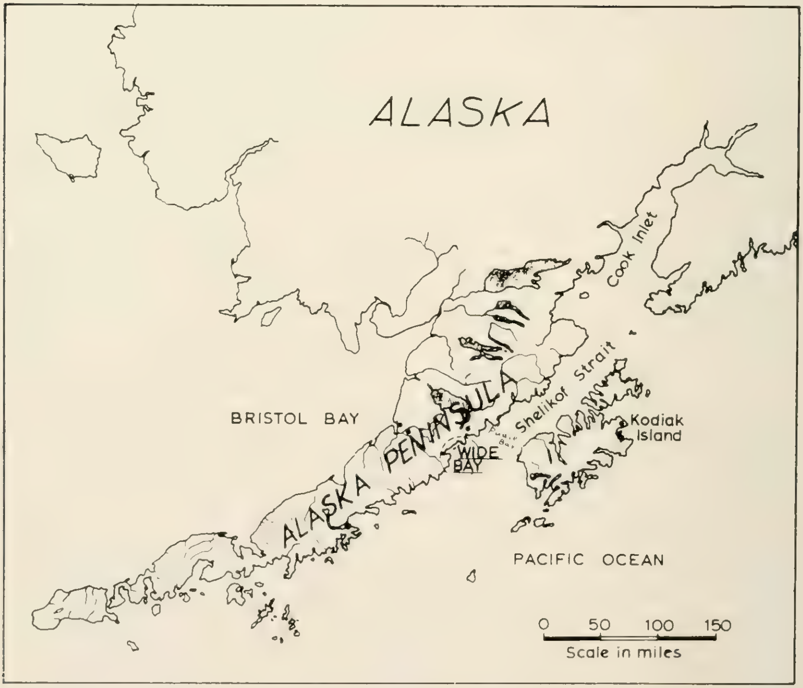
A detailed review, up to the first quarter of this century, of the literature on the Lower Bajocian (Aalenian) Wide Bay fauna and the stratigraphy of the Kialagvik formation was given by Martin (1926, p. 186).

The first description of Bajocian ammonites from Wide Bay was published by White (1889) on a small collection of fossils from the shore of "Kialagvik (or Wrangel) Bay", now called Wide Bay. The exact location was almost certainly the sea cliff exposing the "*howelli* beds" (herein) of the basal *E. howelli* Zone between the mouths of Pass Creek and Short Creek. Significantly, White (p. 194) introduced this fauna as follows: "Seven species are represented in this collection, all of which apparently yet undescribed." These are "*Cucullaea increbescens* sp. nov.", "*Glycimeris ? dalli* sp. nov." [*Pleuromya*], two "Belemnites—?", and the three most abundant ammonite species "*Am. (Lillia) howelli* sp. nov.", "*Am. (Lillia) kialagvikensis* sp. nov.", and "*Am. (Amaltheus) whiteavesi* sp. nov.". This assemblage was dated by White as "somewhat older than Cretaceous. . . . of Liassic or Jurassic age".

These three species have since baffled a number of reviewing authorities on ammonites from all over the world in regard to their generic affinity and age. Thus Haug (1892-93, p. 703, see Martin, 1926, p. 187) referred *A. howelli* to *Hammatoceras, A. kialagvikensis* to *Grammoceras* "near *G. toarciensis* (Orb.)", and *A. whiteavesi* to *Harpoceras* "extremely near to *H. lythense* (Young)" and concluded their "very probable Liassic age". Holzapfel (1892, p. 155 see Martin, *loc cit.)* referred one of the former two species to *Perisphinctes* and believed the assemblage to be of Volgian (latest Jurassic) age (see Martin, *loc. cit.).* Pompeckj (1900, p. 275) assigned the former two species to *Hammatoceras* and the latter to *Harpoceras* "ex gr. *exarati* Young & Bird." confirming a late Liassic age.

New collecting of the Kialagvik fauna was made by Dall in 1895 and its study undertaken by Hyatt (1896, p. 907). Based on a thorough investigation of all known hammatoceratids he concluded (correctly), regarding the "peculiar" Alaskan hammatoceratids, that "the nearest relatives heretofore found belong to the lowest parts of the Inferior Oolite, in formations placed by many German and French authors in the Upper Lias", *i.e.* the early Lower Bajocian (or early Aalenian) which was referred to the Lias by many continental European geologists and still is regarded as such by French colleagues (Lexique Strat. Internat., vol. 1, fascs. 4aIV, 4aV, 1956).

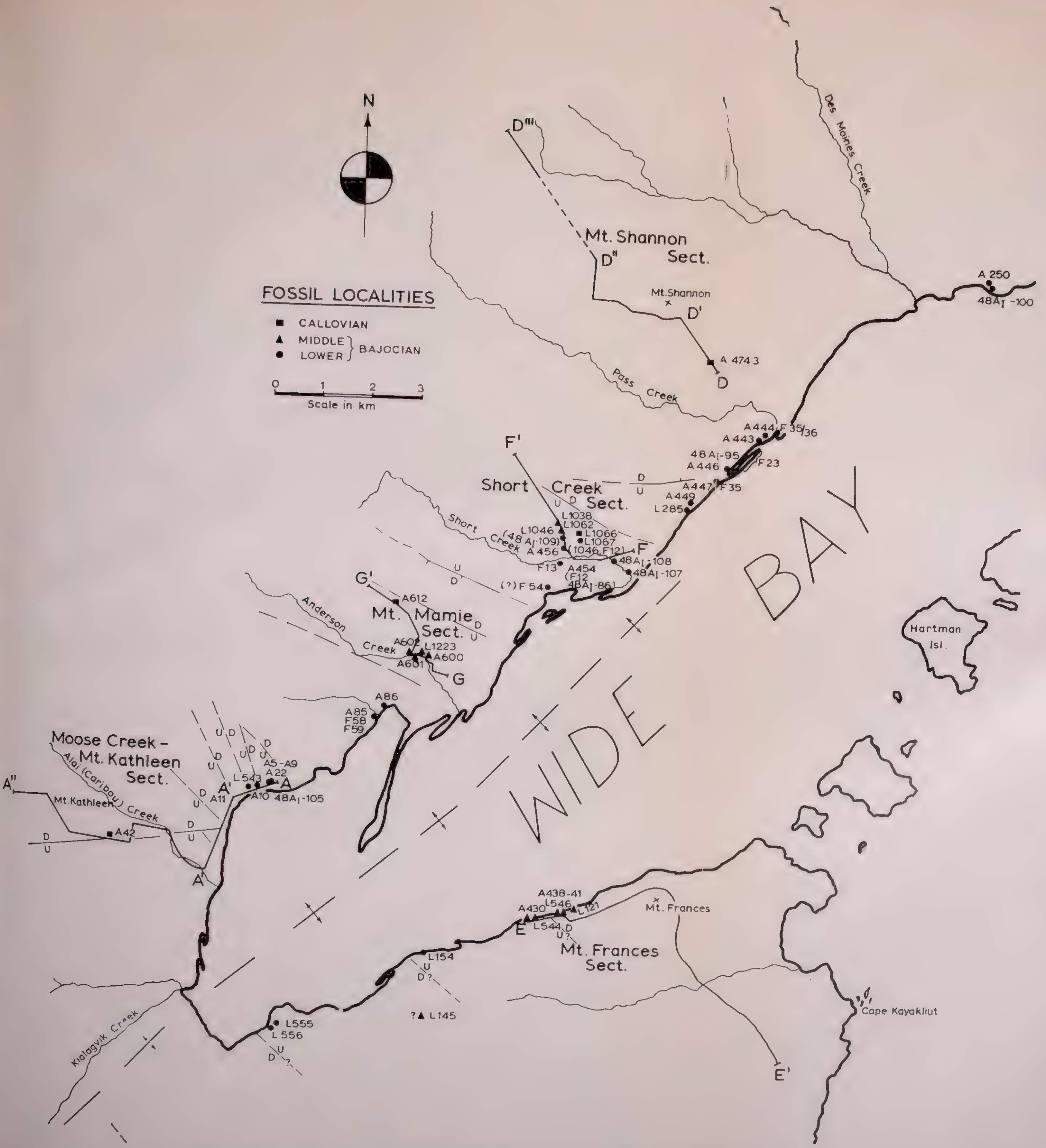
Wide Bay was again visited by Capps in 1921 (1922), who for the first time studied and described the rock sequence which he called the Kialagvik formation. His fossil collections, as well as


ALASKA
Cook Inlet
Shelikof Strait
Kodiak Island
BRISTOL BAY
ALASKA PENINSULA
Puale Bay
WIDE BAY
PACIFIC OCEAN
0 50 100 150
Scale in miles

Text-fig. 1. General map of south Alaska indicating locations of Wide Bay and Puale Bay on the Peninsula.

Moose Creek –
Mt. Kathleen
Sect.
A''
Alai (Caribou) Creek
Mt Kathleen
A42
A'
A11
A'
U D
U D
D U
D U
D U
Kialagvik Creek

Text
local
(oth


N
FOSSIL LOCALITIES
■ CALLOVIAN
▲ MIDDLE
● LOWER
BAJOCIAN
0 1 2 3
Scale in km
Des Moines Creek
D'''
Mt. Shannon Sect.
D''
Mt. Shannon
D'
A 474 3
D
A 250
48AI -100
Pass Creek
A444
F 35/36
A443
48AI-95
F23
A446
A447
F35
A449
L285
F'
Short Creek Sect.
L1038
L1062
L1046
(48 AI-109)
L1066
L1067
A 456
(1046,F12)
F
48AI-108
48AI-107
F13
A454
(F12
48AI-86)
(?) F 54
Short Creek
G'
A612
Mt. Mamie Sect.
Anderson Creek
A602
L1223
A600
A601
G
A86
A85
F58
F59
BAY
WIDE
Hartman Isl.
Moose Creek - Mt. Kathleen Sect.
A''
Alai (Caribou) Creek
Mt.Kathleen
A42
A5-A9
A22
L 543
A'
A
A11
A10
48AI-105
A
A438-41
L546
A430
L121
Mt. Frances
E
L544
Mt. Frances Sect.
L154
?▲ L145
Cape Kayakliut
L555
L 556
Kialagvik Creek
E'
D
U

Text—fig. 2. Index map of Wide Bay Bajocian and some Callovian fossil localities of Shell Oil Company (prefixes A, B, L) and U.S. Geol. Survey (others) indicated with their field numbers. Sections measured by Shell Oil Co.; structural interpretation according to Kellum, *et al.* (1945).

those collected by Smith (Smith and Baker, 1925), were studied by Stanton (in Capps, 1922). The latter concluded that these faunas belong to the "lower part of the Middle Jurassic rather than to the Lias or Lower Jurassic" and, also correctly, inferred that the lower Kialagvik formation (*i.e.* the *E. howelli* Zone) "is not much older than the lowest fossiliferous bed of Tuxedni Bay section and that this horizon may well be included in the Tuxedni formation. . . . It is either basal Tuxedni or slightly older". We know now that the *E. howelli* Zone is represented in the basal Tuxedni formation of the Cook Inlet area (below). However, Stanton's collection probably included single specimens derived from the overlying Middle Bajocian beds of Wide Bay, compared by him to forms known from the middle part of the Tuxedni. These are *"Sonninia ?"*, *"Stephanoceras ?"*, and *"Dactylioceras ?"*. While the first two specimens may possibly be spinose *Erycitoides* or *Eudmetoceras s.s.* and *Erycites,* or *Abbasites,* respectively, from the *E. howelli* Zone, the latter specimen probably is a *Parabigotites* from the Middle Bajocian.

Martin (1926), in his own monograph, followed Stanton in the species determinations and suggested age correlations.

The first detailed geological map (1:48,000) and stratigraphical recordings of fossil assemblages of the southwest side of Wide Bay, in conjunction with findings at Puale Bay (formerly Cold Bay) 70 km. N.E. of Wide Bay, was published by Kellum, Daviess, and Swinney (1945). Mainly based on the Short Creek and Anderson Creek (here "Mt. Mammie") sections, and the sea cliff between Pass and Short Creeks a rather elaborate zonal and subzonal succession was proposed. The limitation of the units was largely lithological which, owing to strong lateral changes in lithofacies, much infringed upon their time-stratigraphic accuracy. The following zones and subzones were distinguished in the Kialagvik formation (from top to bottom, see Text-fig. 3):

1. "*Dactylioceras-Inoceramus* sp. C zone"	(a) *Inoceramus* sp. C subzone [*I. lucifer* Eichw.?] (b) *Dactylioceras* subzone [*Parabigotites crassicostatus* Imlay.]

2. *"Hammatoceras"* zone
(a) *Hammatoceras ? kialagvikensis* subzone.
[*E.* (*Kialagvikes*) *k.* (White)]
(b) *"Hammatoceras" howelli* subzone
[*E. howelli* (White)]

This sequence was said to be disconformably overlain by the *"Seymourites-Inoceramus* sp. E. zone" of early Callovian age. The generic affinity of the nominal species remained unsolved. The *"Hammatoceras"* Zone was based on the supposed stratigraphic range of "*'H'. howelli*", its subzones were faunally poorly defined by the supposed difference in abundance of the two nominal "species", as then frequently understood, aproximately corresponding to the subgenera *Erycitoides* and *E.* (*Kialagvikes*), respectively. This zonal definition still stands, while these "subzones", said to be about 300 and 65 m. thick, are here omitted in favour of a preliminary subdivision in the Lower, Middle, and Upper *E. howelli* Zone. Kellum's (*et al.*) subzonal boundary probably lies about in the middle of the Upper *E. howelli* Zone, *i.e.* halfway between his "F 12" horizon, which is in the Middle *E. howelli* Zone, and the top of the *E. howelli* Zone. However, in "F 12" *"H. ? kialagvikensis"* already occurs abundantly. The highly fossiliferous "bluffs" south of the mouth of Pass Creek of the *E. howelli* zonule (*nom. nov.*) were correlated tentatively with some beds in the upper part of the "*'H.' howelli* subzone" of the Short Creek section, *i.e.* approximately with the Middle *E. howelli* Zone. According to new evidence, however, this zonule belongs at the base of the *E. howelli* Zone, as here defined. According to the fossil locality plots, Kellum's (*et al.*) "*'Hammatoceras'* zone" did not include the lowest, at least 100 m. thick, poorly exposed, and apparently poorly fossiliferous beds containing *Tmetoceras scissum* (in the *scissum* 'zonule') from near the mouth of Short Creek (loc. 48 A_1-107).

Kellum, *et al.* (1945) did not describe any other ammonites but the three species already known to White, from the *E. howelli* Zone, tentatively referred by them to *Hammatoceras* and *Harpo-*

ceras, although "25 species of ammonites and pelecypods" were reported from the "*'H.' howelli* subzone" and 29 from the "*H.* ? *kialagvikensis* subzone". However, besides White's species, "*'Hammatoceras'* spp. B, D, E, and G" as well as "*Pteria* sp. B" and "*Gervillia* sp. A" were listed. Of these "*'H.'* spp. E and G" and the "*Gervillia* sp. A" were said to be known only from the upper "subzone". The zone was referred to the Middle Jurassic, though this was not substantiated by new paleontological evidence.

Kellum, *et al.* also studied the at least 750 m. thick partly volcanic series at "Cold Bay" (Puale Bay), about 70 km. northeast of Wide Bay which was dated as Lower Jurassic, based on a fossil assemblage of "*Arietites* ? sp. A, *Arieticeras* sp. A, and *Harpoceras* sp. C" from about the middle of the series. This faunule is possibly of Pliensbachian age, but no opinion can be based on the figures given only for the latter two species. According to Imlay (1952, p. 979) the representation of Hettangian, Pliensbachian, and Toarcian is suggested from this and other collections. As this series is unconformably overlain by the Lower Callovian "*Seymourites-Inoceramus* sp. E zone" of the Shelikof formation, the Bajocian (incl. Aalenian) beds are apparently missing. This volcanic series may underlie the Lower Bajocian sequence at Wide Bay in the subsurface.

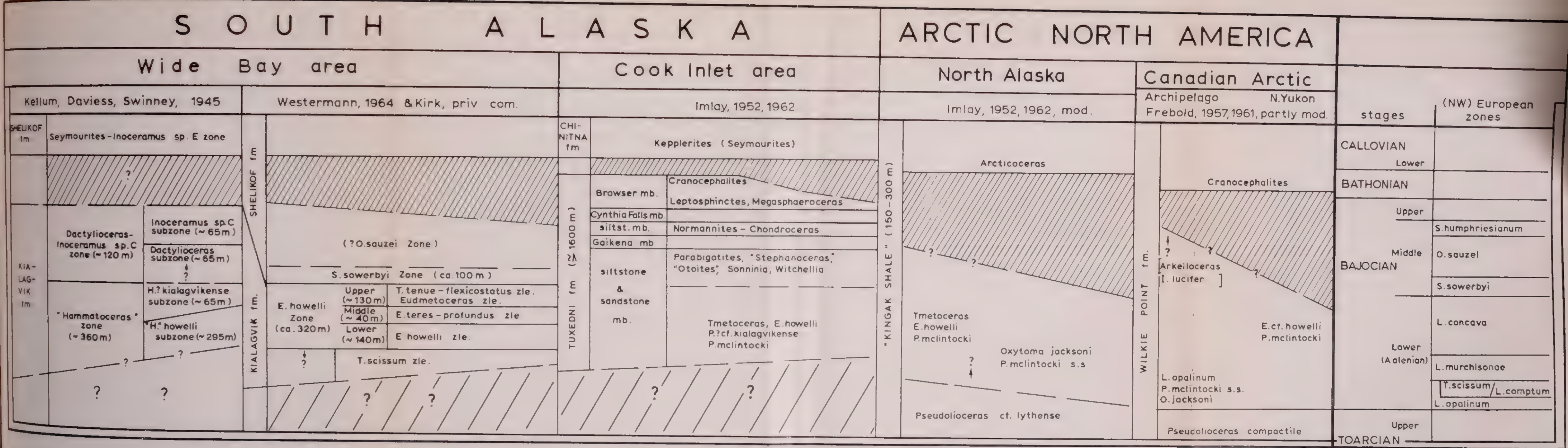
R. W. Imlay and Don J. Miller, from the U.S. National Museum and Geological Survey, in 1948 again visited Wide Bay and collected from most of Kellum's (*et al.*) section, as well as from some important new adjacent exposures. No separate report has been published but the significant results were included in the explanations to the Jurassic correlation charts of United States (Imlay 1952, pp. 987-79). Major paleontological deviations, from and additions to Kellum's (*et al.*) report on the *E. howelli* Zone, were the affiliation of *Am. whiteavesi* White to *Pseudolioceras,* of *Am. howelli* White and *Am. kialagvikensis* White to *Erycites,* and the first report of a world-wide Lower Bajocian (Aalenian) ammonite genus, *i.e. Tmetoceras.* The few representatives of *Hammatoceras* and *Sonninia* mentioned from this zone however, belong to *Eudmetoceras* or spinose *Erycitoides howelli* and to *Erycitoides paucispinosus, sp. nov.,* respectively, described herein. Imlay (*loc. cit.*) also was the first to recognize the *S. sowerbyi* Zone in the overlying ammonite assemblage, although some generic affiliations need revision; *"Emileia"* and *"Erycites"* belong to the *Docidoceras-Pseudotoites* complex, *"Sonninia"* includes several other Sonniniidae genera and the "oppeliids" probably the hammatoceratid *Eudmetoceras (Euaptetoceras)* and possibly strigoceratids. The next higher fossil assemblage was said to contain *Stemmatoceras, Lissoceras, Leptosphinctes* [=*Parabigotites crassicostatus* Imlay, 1962], and, again, *"Emileia"* [=? *Otoites* in Imlay, 1962], and an "oppeliid". These beds were correlated with the *O. sauzei* Zone. A description of this assemblage is in preparation by Imlay (priv. comm.).

The extensive collections of Kellum, *et al.,* and of Imlay and Miller are re-studied in this monograph.

Imlay (1952, pp. 980-81) also substantiated by faunal evidence the correlation of the lower Kialagvik formation (*E. howelli* Zone) of the Wide Bay area with the basal part of the Tuxedni formation in the Cook Inlet area. The Tuxedni formation is exposed at Tuxedni Bay and is present in the subsurface on the Iniskin Peninsula [*E.* cf. *kialagvikensis* (White) was confirmed by the writer].

Apparently the same assemblage of *E. howelli, Tmetoceras* sp., and *Pseudolioceras mclintocki* (Haughton) was finally also recovered from the "Kingak shale" on the Arctic slope of Alaska (Imlay 1955). However, the contemporaneity of the species could not yet be demonstrated because they occur mostly isolated in exposures of unknown stratigraphic interrelation; *Tmetoceras* was found only in a drill core. The interval containing this fauna is underlain by Toarcian and is generally disconformably overlain by uppermost Bathonian sediments, with the local representation of Bajocian beds younger than the *E. howelli* Zone.

Arkell (1956, pp. 537-38) again briefly discussed this ammonite assemblage, based on the literature here reviewed, and suggested that the "peculiar ammonites" *i.e. Am.* (*Lillia*) *howelli* and *Am. kialagvikensis* do not belong to any genus previously referred to, *i.e.* by inference they belong to a genus not yet described. Based on (a) the abundance of *Pseudolioceras* and the alleged correlation with the Toarcian *Pseudolioceras* beds of eastern Greenland, and (b) on Imlay's report of *"Sonninia"* from the same assemblage, he


SOUTH ALASKA
ARCTIC NORTH AMERICA
Wide Bay area
Cook Inlet area
North Alaska
Canadian Arctic
Kellum, Daviess, Swinney, 1945
Westermann, 1964 & Kirk, priv com.
Imlay, 1952, 1962
Imlay, 1952, 1962, mod.
Archipelago
N.Yukon
Frebold, 1957, 1961, partly mod.
stages
(NW) European zones
SHELIKOF fm
Seymourites-Inoceramus sp. E zone
?
KIA-LAG-VIK fm
Dactylioceras-Inoceramus sp.C zone (~120 m)
Inoceramus sp.C subzone (~65m)
Dactylioceras subzone (~65m)
?
H.? kialagvikense subzone (~65m)
"Hammatoceras" zone (~360m)
"H." howelli subzone (~295m)
?
?
?
?
SHELIKOF fm
KIALAGVIK fm.
(?O.sauzei Zone)
S.sowerbyi Zone (ca.100 m)
E. howelli Zone (ca.320m)
Upper (~130m)
Middle (~40m)
Lower (~140m)
T. tenue-flexicostatus zle.
Eudmetoceras zle.
E.teres-profundus zle
E howelli zle.
?
T.scissum zle.
?
?
CHI-NITNA fm
TUXEDNI fm (≳1600 m)
Kepplerites (Seymourites)
Browser mb.
Cranocephalites
Leptosphinctes, Megasphaeroceras
Cynthia Falls mb.
siltst. mb.
Normannites - Chondroceras
Gaikena mb
siltstone & sandstone mb.
Parabigotites, "Stephanoceras," "Otoites," Sonninia, Witchellia
Tmetoceras, E.howelli
P.?cf.kialagvikense
P.mclintocki
?
?
"KINGAK SHALE" (150-300 m)
Arcticoceras
?
?
Tmetoceras
E.howelli
P.mclintocki
Oxytoma jacksoni
P.mclintocki s.s
?
Pseudolioceras cf. lythense
WILKIE POINT fm.
Cranocephalites
?
?
?
Arkelloceras
[I. lucifer]
E.cf.howelli
P.mclintocki
L.opalinum
P.mclintocki s.s.
O.jacksoni
Pseudolioceras compactile
CALLOVIAN
Lower
BATHONIAN
Upper
Middle
BAJOCIAN
Lower (Aalenian)
Upper
TOARCIAN
S.humphriesianum
O.sauzei
S.sowerbyi
L.concava
L.murchisonae
T.scissum/L.comptum
L.opalinum

Text—fig. 3. Correlation chart of Lower Bajocian formations in northwestern North America.

also suggested that this may be a condensed fauna, but he described it under the heading of *"Toarcian ?"*

The *E. howelli* Zone ammonite fauna was also discussed recently by Sato (1957, p. 332), who came to a similar conclusion as Arkell (*loc. cit.*). Sato returned to the inclusion of *E. howelli* in *"Lillia"* [=*Phymatoceras*], retained Haug's opinion that *E. kialagvikensis* is a near relative of *Grammoceras toarciense* (d'Orb.) and, consequently, again believed in a Toarcian age for these species. *Tmetoceras,* and the alleged *"Hammatoceras"* and *"Sonninia"* reported by Imlay (1952) from the same assemblage at Wide Bay, however, were supposed to come from a younger horizon correlated by Sato with the Lower Bajocian (Aalenian) *Hammatoceras* Zone of Japan. Sato noted the remarkable resemblance between Imlay's (1955) *Pseudolioceras* cf. *lythense* and *P.* cf. *compactile* from the Toarcian of northern Alaska with his (supposed) *Hyperlioceras* from the Japanese *"Hammatoceras"* [=*Planammatoceras*] -*Tmetoceras* assemblage. The Japanese *"Hyperlioceras"* (Pl. 53, figs. 7, 8) is here presumed to belong, at least in the main to *Pseudolioceras,* and the same appears to be true for his *"Graphoceras"* (Sato, 1958, pl. 13, figs. 11?, 12, 13). The *E. howelli* Zone only approximately correlates with the Japanese *"Hammatoceras* zone", dated as late Early Bajocian (late Aalenian) by Sato (p. 155), *i.e.* the *E. howelli* Zone may be slightly younger. No *Planammatoceras* is known from North America and, alternately, no *Erycitoides* and *E.* (*Kialagvikes*) from Japan.

In recent years the Wide Bay area has been mapped intensively by Shell Oil Company (Seattle, Wash.) based on lithogenetic-cartographic units. Large accurately collected fossil assemblages were made, of which those from the Kialagvik formation were kindly loaned to the writer by Mahlon V. Kirk, Shell paleontologist. Most of the new stratigraphic and tectonic data are, of course, still confidential and cannot yet be published. According to Kirk (priv. comm.), however, the new stratigraphic and paleontologic findings have altered appreciably the geological interpretation by Kellum, Daviess, and Swinney (1945), and Imlay (1952) of the area. Most pertinent information regarding the stratigraphic correlation of the fossil localities and compilation of the sections were kindly made available and are the basis for Text-figures 2 and 5. The

Kialagvik/Shelikof formational boundary is now drawn approximately 100-300 m. lower than by Kellum, *et al.,* and Imlay. It has lost its identity with the supposed Lower Callovian unconformity and, instead, transgresses biostratigraphic units ranging from the top of the *E. howelli* Zone to the tentatively supposed *O. sauzei* Zone (Text-fig. 4).

Frebold (1959, 1960) extended the known lateral distribution of the *Erycitoides-Pseudolioceras* assemblage to northeastern Yukon, where *E.* cf. *howelli* (White) and *Pseudolioceras* cf. *P. mclintocki* (Haughton) occur near Bonny Lake in the northeastern Richardson Mountains. He also suggested the possible synonomy of *P. whiteavesi* (White), 1889, with *P. mclintocki* (Haughton), 1858.[1] The former is here regarded as a subspecies of the latter. *P. mclintocki* is, however, not restricted to the *L. opalinum* Zone in which it occurs on Melville and probably also on Prince Patrick Islands *(op. cit.),* although this may possibly be the case for the restricted species. *P. mclintocki whiteavesi* is probably younger and a typical member of the *E. howelli* Zone assemblage. *Leioceras opalinum* (Rein.) is unknown from the North American continent.

STRUCTURE

According to Kellum, Daviess, and Swinney (1945) the Jurassic system of this area is elevated in the S.W.-N.E. trending Wide Bay anticline covering more than 750 square kilometres (Text-fig. 2); but only 75 square kilometres in the southwest are moderately well known and have been mapped on a small scale *(op. cit.).* The southwestern termination of the anticline is said to be at the head of Kialagvik Creek where large masses of extrusive and intrusive bodies are present. Other igneous intrusives separate this anticline from the Bear Creek-Salmon Creek anticline, its supposed northeastern continuation, commencing at Portage Bay.

Further description of the Wide Bay anticline was given as follows *(op. cit.,* p. 11):

> The axial part of the anticline is concealed beneath Wide Bay and beneath the alluvium extending southwest from the head of the Bay. The position of the axis and the attitude of its axial plane therefore must be determined from

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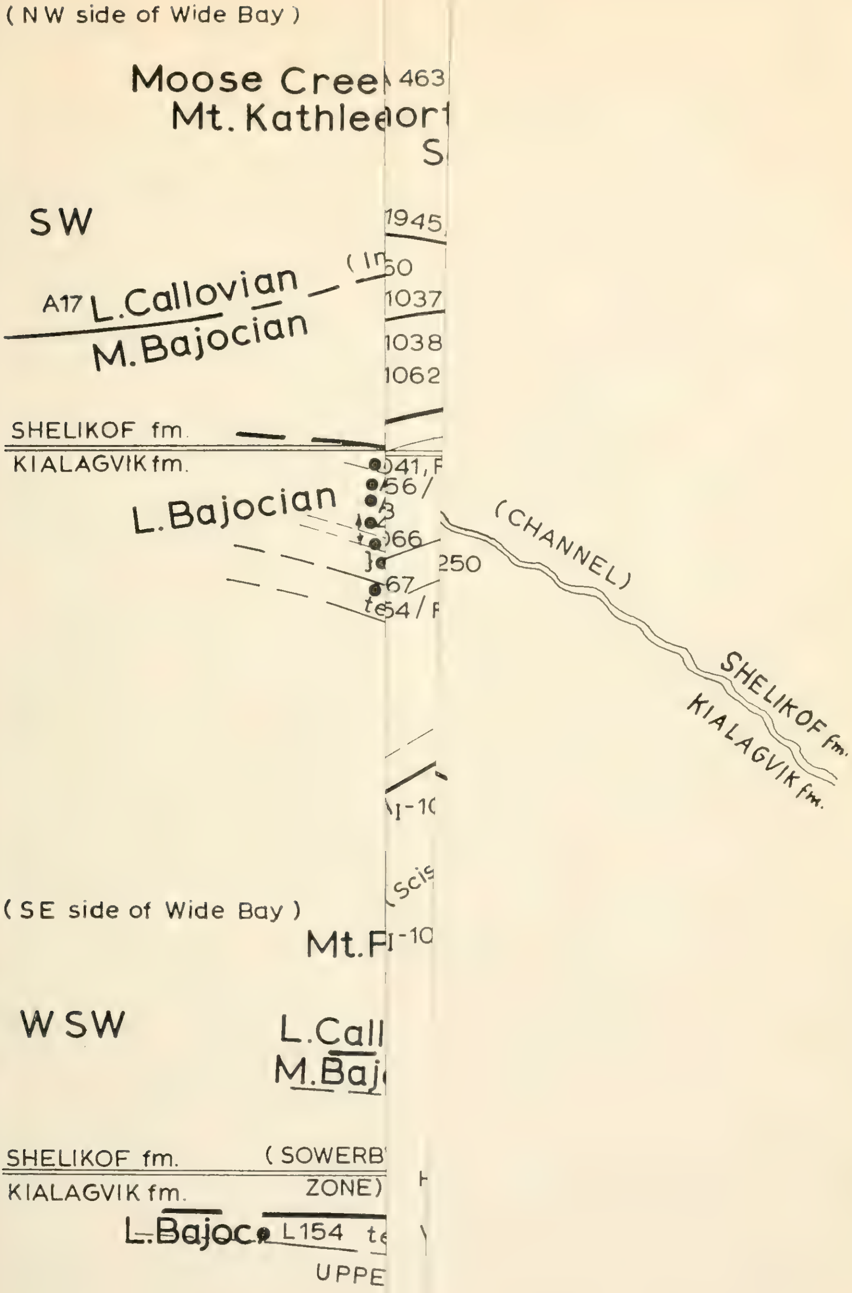
[1] The original spelling *"A. m'clintocki"* followed by Frebold is here corrected to *P. mclintocki,* in accordance with the nomenclatorial regulations.


(N W side of Wide Bay)
Moose Cree
463
Mt. Kathlee
ort
S
SW
1945
(In
50
A17 L.Callovian
1037
M.Bajocian
1038
1062
SHELIKOF fm.
KIALAGVIK fm.
041, F
56/
3
L.Bajocian
066
250
67
te
54 / F
(CHANNEL)
SHELIKOF fm.
KIALAGVIK fm.
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(Scis
(SE side of Wide Bay)
Mt. F
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W SW
L.Call
M.Baj
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(SOWERB
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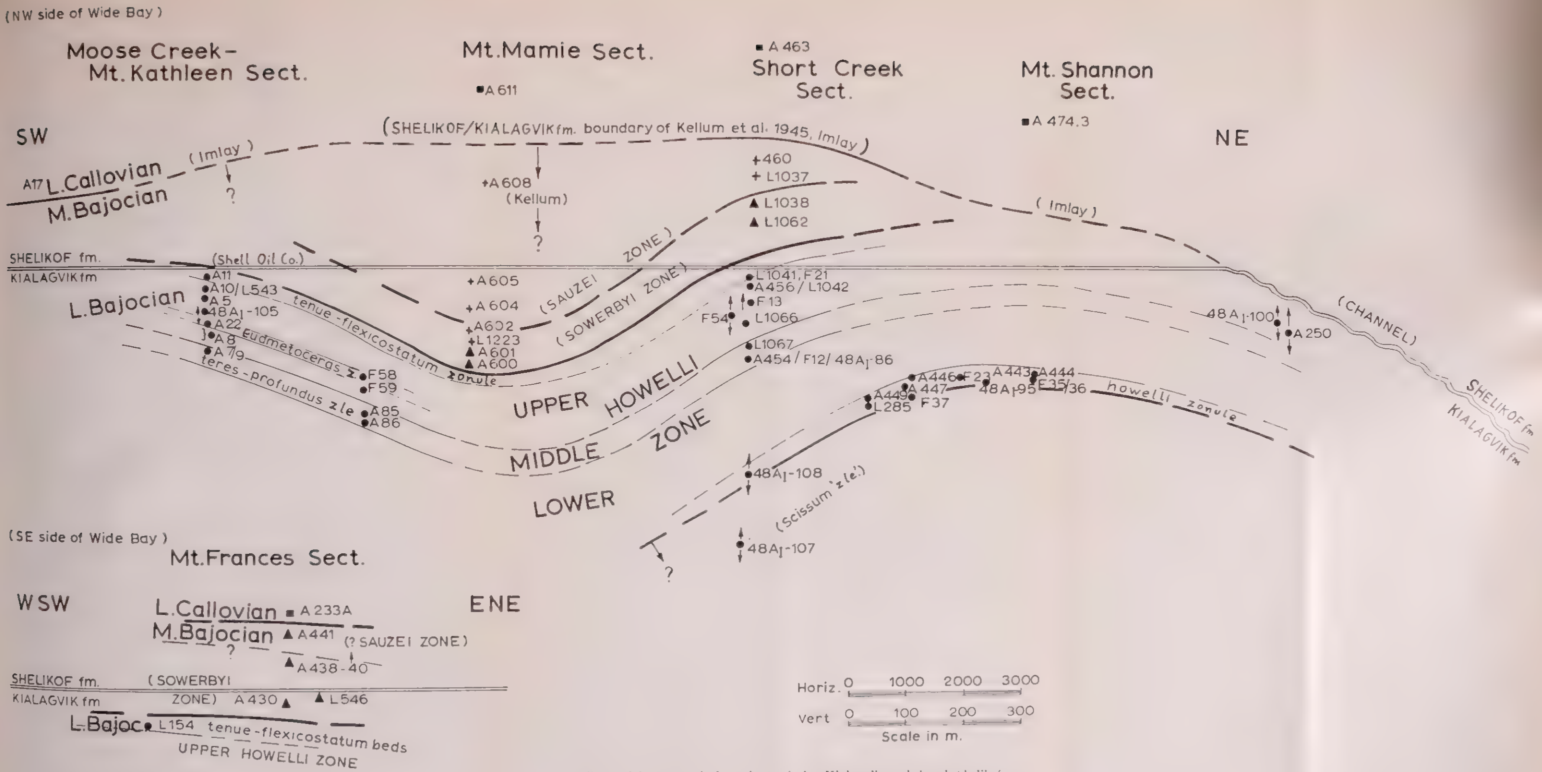
(NW side of Wide Bay)
Moose Creek-Mt. Kathleen Sect.
Mt. Mamie Sect.
A 611
A 463
Short Creek Sect.
Mt. Shannon Sect.
A 474.3
SW
NE
(SHELIKOF/KIALAGVIK fm. boundary of Kellum et al. 1945, Imlay)
(Imlay)
A17 L.Callovian
M.Bajocian
?
A608
(Kellum)
?
460
L1037
L1038
L1062
(Imlay)
SHELIKOF fm.
KIALAGVIK fm
(Shell Oil Co.)
(SAUZEI ZONE)
(SOWERBYI ZONE)
A11
A10/L543
A5
48AI-105
A22
A8
A7/9
L.Bajocian
tenue-flexicostatum zonule
Eudmetoceras z.
teres-profundus zle
F58
F59
A85
A86
A605
A604
A602
L1223
A601
A600
L1041, F21
A456/L1042
F13
F54
L1066
L1067
A454/F12/48AI-86
48AI-100
A250
(CHANNEL)
SHELIKOF fm
KIALAGVIK fm
A446
F23
A443
A444
A449
L285
A447
F37
48AI-95
F35/36
howelli zonule
UPPER HOWELLI
MIDDLE ZONE
LOWER
48AI-108
(Scissum zle.)
48AI-107
?
(SE side of Wide Bay)
Mt.Frances Sect.
WSW
ENE
L.Callovian
A233A
M.Bajocian
A441
(? SAUZEI ZONE)
?
A438-40
SHELIKOF fm.
KIALAGVIK fm
(SOWERBYI ZONE)
A430
L546
L.Bajoc.
L154
tenue-flexicostatum beds
UPPER HOWELLI ZONE
Horiz. 0 1000 2000 3000
Vert 0 100 200 300
Scale in m.

Text—fig. 4. Diagrammatical sections of the Kialagvik and basal Shelikof formations of Wide Bay as measured and interpreted by Shell Oil Company Plane of reference is the formational boundary (boundary according to Imlay, 1952, p. 62, and Kellum, *et al.*, 1945, indicated); all additional features such as a number of major faults are omitted. Plot of Shell locations (prefixes A, B, L) by M. Kirk, plot of U.S. Geol. Survey locations (others) by the writer. As is evident from the datum, *i.e.* the only shown purely lithologic line, the rock-stratigraphic units strongly transgress time, *i.e.* the biostratigraphic boundary lines. However, the record is partly obscured and incomplete

> the stratigraphic position and dip of the beds exposed along the flanks. Dips of 12 to 20 degrees were observed on the southeast flank of the Wide Bay anticline, and 4 to 17 degrees on the northwest flank. The axis trends approximately N50° E along the central part of the Bay, and because of the slightly steeper dips on the southeast flank, the axial plane probably dips steeply to the northwest.
>
> At one locality near the head of Kialagvik Creek, unfossiliferous sandstone referred tentatively to the *Dactylioceras-Inoceramus* sp. C zone [Mid-Bajocian] of the Kialagvik formation is nearly flat and is interpreted to be on the axis of the anticline. The possibility of faulting along the axial part of the anticline is one factor that makes uncertain the exact position of the axis as shown on the map. . . . Dips of 6, 7, and 12 degrees to the south and southwest around the nose indicate the plunging end of the fold.
>
> From the large number of small faults and the few larger ones observed along the flanks of the Wide Bay anticline, it is evident that the anticline is complicated by a series of transverse displacements. . . . Most of the faults in the area mapped trend northwesterly and dip steeply. Displacements are estimated to be as much at 900 feet but the displacements along most faults are much less.

The authors then proceed to describe the major faults mapped on the southwest side of Wide Bay. In all faults the northeastern side is said to be downthrown, except for the one just south of Short Creek. Thus a horst is developed in the Short Creek area with a southwesterly adjoining graben. The major structural features of the anticline, as shown on Kellum's *(et. al.)* geological map, were traced on the index map (Text-fig. 2). As stated above, the new extensive field studies carried out by Shell Oil Company have changed this picture appreciably, but the results will not be available for publication for a few years.

STRATIGRAPHY

The oldest Jurassic beds known in the Alaska Peninsula (Text-fig. 3) are an approximately 700 m. thick sedimentary series interbedded with volcanics at Puale Bay (formerly Cold Bay), 70 km. northeast of Wide Bay (see Kellum, *et al.*, 1945, p. 3, 4). According to Imlay (1952, p. 979) the representation of the Hettangian, Pliensbachian, and Toarcian stages is suggested by ammonite faunas. This sequence is probably unconformably overlain by the coarse conglomerate of the Shelikof formation and the Kialagvik formation is missing. The lower Jurassic volcanic series [? Talkeetna formation] apparently underlies the Kialagvik formation in the Wide Bay area.

The Kialagvik formation which is known to outcrop extensively only in the southwestern part of the Wide Bay anticline consists of about 400 to 600 m. argillaceous and arenaceous nonvolcanic sediments. The basal 100 m. unit is poorly exposed near the mouth of Short Creek and is older than any previously described beds from Wide Bay. It appears to be largely pelitic and has yielded only two specimens of large typical *Tmetoceras scissum* (Ben.) at locality 48 A_1-107 (12247). *Tmetoceras scissum* zonule is tentatively proposed for this horizon.

The overlying approximately 300-350 m. unit, "chiefly consisting of interbedded sandstone and shales" and reported to become "progressively somewhat coarser-grained from the bottom toward the top", was named the "*'Hammatoceras'* zone" by Kellum, *et al.* (1945, p. 5). "It outcrops almost continuously in the cliffs along the northwest side of Wide Bay from south of Pass Creek to near the southwest end of Wide Bay. . . . Two rather well-defined cycles of sedimentation are included. . . . and each of these is characterized by a faunal assemblage. They are designated as subzones—the lower one the *'Hammatoceras' howelli* subzone and the higher the *Hammatoceras ? kialagvikensis* subzone" *(loc. cit.).* Almost 300 m. of probably "largely dark-grey to black shale with platy sandstone" in the lower part, probably becoming "coarse-grained and with more abundant platy sandstone" *(loc. cit.)* in the upper, were included in the "*'H.' howelli* subzone". This "subzone" is equivalent to the Lower, Middle, and probably basal Upper *E. howelli* Zone as described here. However, the supposedly 55 m. of "largely greenish-gray shaly sandstones with concretionary nodules of sandstone up to several feet in diameter" which are exposed "in the low bluffs between Short and Pass Creeks" and abound in *Erycitoides howelli* (White) were "believed to correspond to the upper part of the section exposed along Short Creek". Also taking into account the statement that "the basal 500 feet [of the Short Creek section] are stratigraphically lower than strata observed anywhere else on the Wide Bay anticline, as determined by paleontological correlation" and Kellum's *(et al.)* plot of fossil locations, it appears probable that the authors had the "F 12" beds in mind which are here placed in the Middle *E. howelli* Zone (all quotations, *loc. cit.).* However, based on stratigraphical correlation by Kirk (priv. comm.) these fossiliferous beds, here included in the *E. howelli* zonule *(nom. nov.)* are at least 100 m. below beds exposed sub-continuously in the Short Creek section; this ammonite assemblage also differs from any higher one (Text-figs. 5, 12). The *E. howelli* zonule is here regarded to form the base of the *E. howelli* Zone although it appears possible that the zone may extend further downward into the above described poorly exposed unit. Significantly, Kellum, *et al.,* (1945, p. 6) assumed the correlation here accepted for locality "F 37" which is just "a short distance southwest of the main fossil locality in the bluffs" and yielded "five species of mollusca. . . . . not diagnostic of the subzone but they do indicate the zone" *(loc. cit.)*. "F 37" is identical to Shell locality A 447 from which typical *E. howelli* was received and which no doubt is in the same horizon, said to be probably between 6 and 15 m. in thickness, as A 443, A 444, A 446, A 449, L 285, F 23, F 35, F 48, F 51, A_1-95 (Text-figs. 2, 7).

The uppermost approximately 65 m. of the *E. howelli* Zone were described as follows (Kellum, *et al.,* 1945, p. 6):

> The best exposures included in the *Hammatoceras ? kialagvikensis* subzone were observed along Short Creek but they also crop out in the sea cliff at a number of localities between Short Creek and the end of the sea cliffs near the southwest end of Wide Bay. The observed thickness of the subzone is about 200 feet including interbedded sandstone, shale, and conglomerate. This conglomerate facies is the dominant character of the subzone. Fossils appear to be most abundant about 150 feet below the lithologic break selected as the top of the subzone. Changes in lithologic character along the beds are an exceptionally common feature of this subzone and intraformational conglomerates were observed.

All of Kellum's *(et al.,* 1945) plotted fossil lots from Short Creek, according to their figure 2, are derived from the mentioned single fossiliferous horizon. However, according to their figure 1 the beds exposed in the different outcrops do not all correlate. It is here assumed that at least three horizons are represented and that the mistake occurred in the drawing of the columnar section. It is, therefore, impossible to compare in detail Kellum's (*et al.*) interpretation of the Short Creek section at this interval with the limited stratigraphic data of Shell Oil Company and U.S. Geological Survey studies available to the author.

The statement that "the sequence of lithological units "[of the *E. howelli* Zone]" implies a regressing sea" (*op. cit.,* p. 16), probably still applies in spite of the stratigraphical modification described above.

According to Shell Oil Company's stratigraphical data (priv. comm. Kirk) and paleontological studies by the writer, the boundary of the Kialagvik Shelikof formations approximately coincides with the top of the *E. howelli* Zone in the Short Creek and Moose Creek-Mt. Kathleen sections but lies as much as 200 m. stratigraphically higher in the intermediately located Mt. Mammie section. At the southeast side of Wide Bay the formational boundary is between 20 and 70 m. above the top of the *E. howelli* Zone.

Overlying the *E. howelli* Zone is a unit said to average 165 m. in thickness and to consist of "interbedded sandstone and shales at the base and the sand content is progressively greater upwards". This unit was called "the most persistent zone in the Wide Bay area" but the authors (Kellum, *et al.,* 1945, p. 7) also stated that "at some places, for example in the Short Creek area and on the southeast side of the Bay. . . . the unit [the basal sandy member] is distinctly more shaly" and "for example near the most southerly part of the bay the unit is somewhat conglomeratic". This is the *"Dactylioceras-Inoceramus* sp. C zone" of Kellum, *et al. (loc. cit.)* which was more or less arbitrarily medially subdivided in the lower *"Dactylioceras* subzone" and the upper *"Inoceramus* sp. C subzone". However, *"Dactylioceras* sp. A" [*Parabigotites crassicostatus* Imlay, 1962] occurs with certainty only near the top of the "subzone" (F 43). This species was said to be accompanied by *Pseudolioceras, Phylloceras, Stephanoceras,* and *Teloceras* in other collections from Wide Bay. Imlay (1962) reported *P. crassicostatus* also from the Tuxedni formation of Cook Inlet, in association with *Stephanoceras* and, locally, *Otoites, Sonninia, Witchellia,* and *Lissoceras,* and proposed a Middle Bajocian age, probably *O. sauzei* Zone. In the Kialagvik formation a rich ammonoid assemblage occurs in the lower part of this member mainly consisting of *Pseudotoites, Sonninia, Witchellia, Strigoceras,* and *Pseudolioceras.* This assemblage, apparently overlooked by Kellum, *et al.*, belongs in the *S. sowerbyi* Zone.

In the *"Inoceramus* sp. C subzone" the nominal species [*I. lucifer* Eichw. ?] abounds in certain beds, but only a single *"Phylloceras* ? sp. A" was found. These beds are included in the Kialagvik formation only in the Mt. Mammie section but are elsewhere regarded as belonging in the Shelikof.

The thickness of the Shelikof formation was originally estimated at 2,000 m. or more by Capps (in Kellum, *et al.*, 1945, p. 8) but between 100 and 250 m., possibly as much as 350 m. are now to be added, in accordance with the redefinition of the lower boundary. The formation consists of a 600-800 m. thick shaly lower member with "some limy lenses and concretions," an approximately 150 m. thick median member of "massive brown to gray sandstones with minor amounts of shale and conglomerate," and an upper 220-320 m. thick member of "massive black shale with some limestone lenses and nodules". These members intergrade not only vertically but also laterally (Imlay, 1952, p. 978). According to Imlay (priv. comm.) the basal Callovian beds, *i.e.* the "*Seymourites-Inoceramus* sp. E zone" of Kellum, *et al.*, are characterized by thin interbedded tuffaceous layers, the lowest occurrence of which was then regarded as an isochronous marker of the Kialagvik/Shelikof formations boundary. No unconformity was noticed in any section and an earlier report of a basal conglomerate was regarded as intraformational (Kellum, *et al.*, 1945, p. 9).

Beds representing Upper Bajocian and Bathonian are at least locally missing; in the Anderson Creek section the "*'Hammatoceras'* zone" is almost directly overlain by the "*Seymourites-Inoceramus* sp. E zone" as based on faunal evidence *(op. cit.,* fig. 2).

At the northeastern end of the area studied, on the northwest side of Wide Bay, the Shelikof formation fills a deep channel in the Kialagvik formation, cut well into the *E. howelli* Zone. However the age of the Shelikof at that spot appears to be unknown (Text-fig. 4).

The middle and upper members of the Shelikof are unfossiliferous at Wide Bay but have yielded *Cadoceras* and *Pseudocadoceras* at Puale Bay indicating that the formation is wholly of Callovian (probably only Lower and Middle Callovian) age (Imlay, 1952, p. 978).

The youngest Mesozoic sediments of the Wide Bay anticline belong to the Naknek formation which overlies the Shelikof with a thick basal conglomerate. The formation includes beds of late Oxfordian and Kimmeridgian, possibly also early Portlandian age. This is based on the presence of *Cardioceras* near the base, *Amoeboceras* (*Prionodoceras*) and *Buchia concentrica* in the middle part, and *Buchia mosquensis* and *B. rugosa* in the upper part of the formation along the Alaska Peninsula.

FAUNAL RELATIONS AND AGE

PRE-E. HOWELLI ZONE BEDS—T. SCISSUM "ZONULE"[2]

The only known exposure (48 A1-107) of the basal Kialagvik formation has yielded *Tmetoceras scissum* (Ben.) proper, which elsewhere from North America has only been confirmed from otherwise barren beds of nonspecified age in the Lower Hazelton group of British Columbia (*"T. regleyi ?"*; Frebold, 1951, p. 18). In South America what is probably a *T. scissum* was described, in supposed association with *Ludwigia* (*Graphoceras*) cf. *L. concava* (Sow.), from the Argentina Andes (Gottsche, 1878; Tornquist, 1898), indicating late Lower Bajocian (Aalenian). *T. scissum* probably ranges in Europe throughout the lower and middle Aalenian (Lower Bajocian), *i.e.* from the *L. opalinum* Zone to the *L. murchisonae* Zone, and flourishes in the Upper *L. opalinum* Zone. A similar range is assumed for the Japanese occurrence; the inclusion of the *S. sowerbyi* Zone in the age equivalence of the *"Hammatoceras* zone", also yielding *"Tmetoceras rectecostatum"* [*T. scissum*], by Sato in 1958 is certainly erroneous. It is, therefore, not possible to accurately determine the zonal correlation of the *T. scissum* "zonule", and *T. scissum* probably ranges well into the *E. howelli* Zone. The writer does not agree with Arkell (1956, p. 585) who stated that the beds with *"Tmetoceras regleyi* (Thiollier)", here regarded synonymous with *T. scissum*, in Argentina "thus correlate with the *T. regleyi* horizon in Canada and the *T. scissum* zone of Europe".[3] The fact, however, that *Tmetoceras* does not accompany

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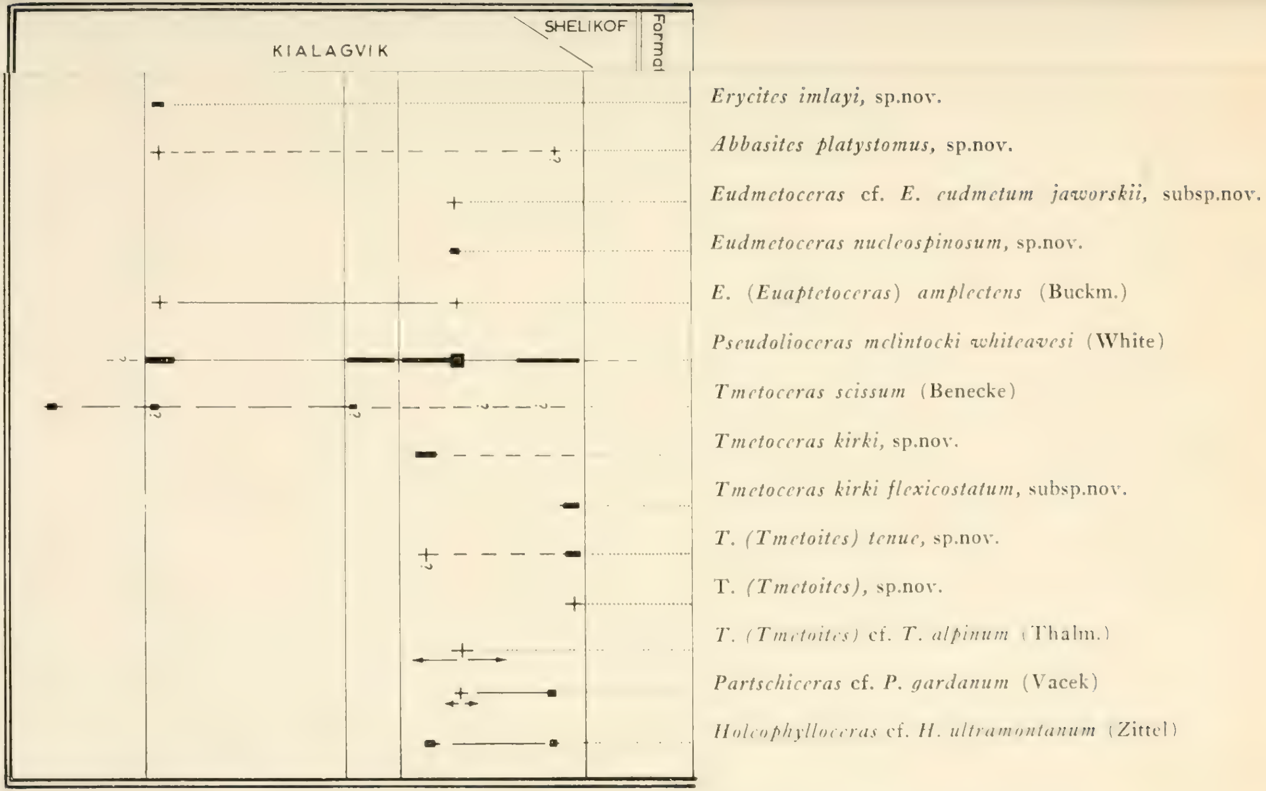
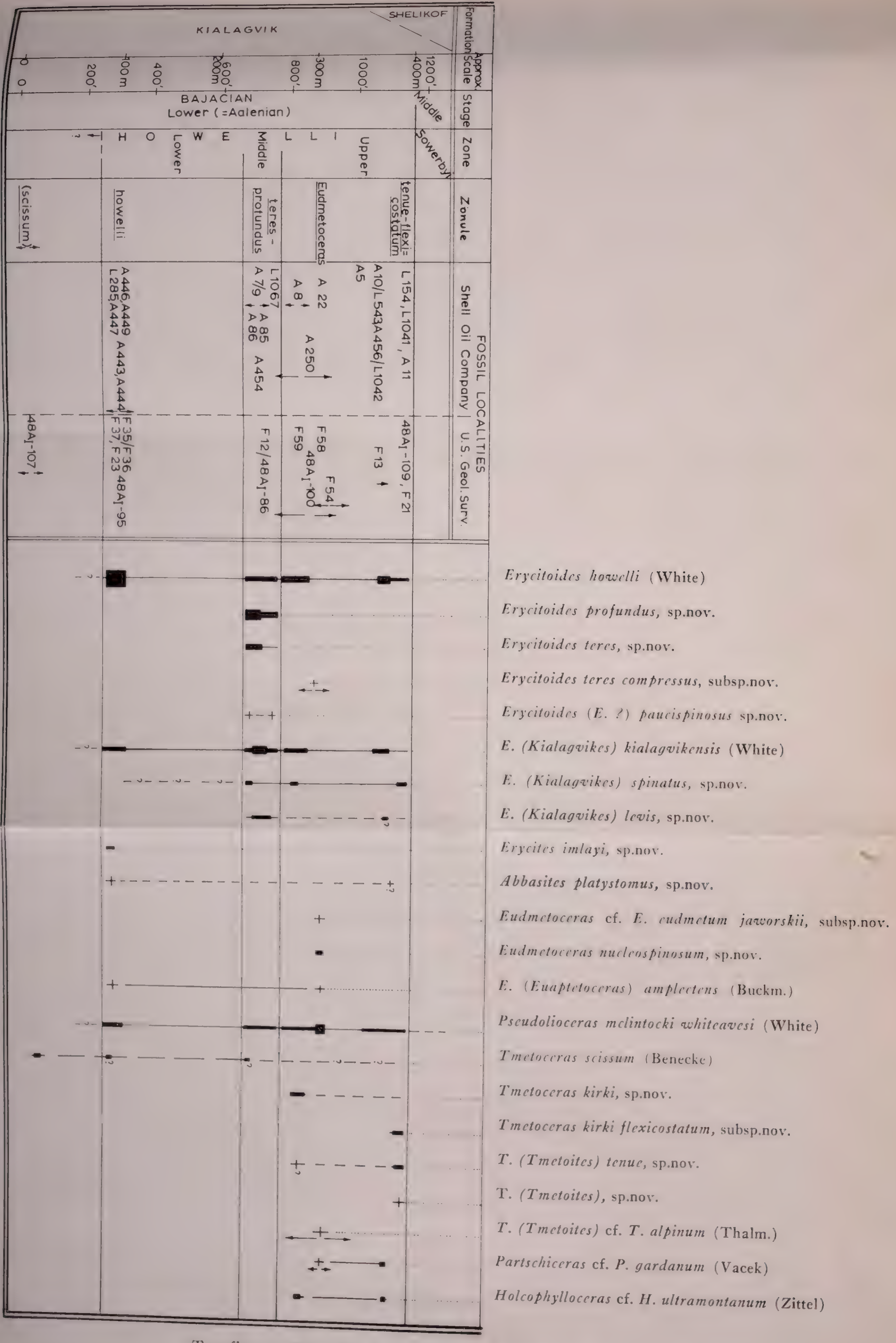
[2] The term "zonule", kindly suggested by Mahlon V. Kirk in reading the manuscript as a replacement for "beds", is here applied for minor biostratigraphic units not sufficiently well known to verify the term "subzone". It is to be emphasized that the biostratigraphic units mentioned here do not coincide with or parallel lithostratigraphic units.

[3] The "scissum zone" in Europe is not equivalent to the *"Sinon"* Zone and *"Tolutaria* zone" [*non Am. tolutarium* Dumortier] but is in the Upper *L. opalinum* Zone. While this paper was in press, H. Rieber (1963, p. 70) recognized a separate *Tmetoceras scissum* Zone between the lower *L. opalinum* and the *L. murchisonae* Zones. It comprises the upper *L. opalinum* Zone in Rieber's new restricted sense, and the *L. comptum* Subzone as here understood is placed in the upper *L. opalinum* Zone (based on Rieber's earlier private communication). According to Rieber (1963) *L. opalinum* probably does not range upward into beds with *L. comptum*. Further studies, particularly outside southern Germany, are required.



Text-fig. 5. The vertical distribution of ammonoid species in the Lower Bajocian (Aalenian) Kialagvik formation of Wide Bay. Relative abundance indicated by thickness, single occurrences by crosses.



Text-fig. 5. The vertical distribution of ammonoid species in the Lower Bajocian (Aalenian) Kialagvik formation of Wide Bay. Relative abundance indicated by thickness, single occurrences by crosses.

L. opalinum in the Canadian Artic Archipelago may possibly suggest that the lowest exposed beds of the Wide Bay anticline are younger than the *L. opalinum* Zone. But Graphoceratidae are altogether missing on the North American continent and any correlation without them appears impossible at present.

E. HOWELLI ZONE[4]

Lower E. howelli Zone, incl. E. howelli zonule.—The first occurrence of the assemblage typical for this zone is known from the extraordinarily rich *E. howelli* zonule at the apparent base of the Lower *E. howelli* Zone. Dominant is a great variety of large *Erycitoides,* all referred to the single species *E. howelli* (White) (Text-fig. 12). Also well represented are *E. (Kialagvikes) kialagvikensis* (White), the corresponding microconch, as well as *Pseudolioceras mclintocki whiteavesi* (White). The three species occur at a relative frequency approximating to the ratios 15:1:2.5. This is based upon the assumption that the Shell and U.S.G.S. collections were made at random in regard to species distribution. The original collection studied by White (1889) and assumed to come from the same beds includes 16 *E. howelli,* 4 (+1?) *E. (Kialagvikes)* cf. *kialagvikensis,* and 3 *Pseudolioceras mclintocki whiteavesi.* Besides these endemic species which range throughout the *E. howelli* Zone, occur the rare *E. (Kialagvikes) levis, Abbasites platystomus, Erycites imlayi, spp. nov.,* and, significantly, *Eudmetoceras* (*Euaptetoceras*) *amplectens* (Buckm.), and *Tmetoceras* cf. *T. scissum* (Ben.). *E. howelli* and *P. mclintocki whiteavesi* are usually associated also at other localities known from Alaska and northeast Yukon only. *P.* cf. *mclintocki* (Haugh.) was found in the *L. opalinum* Zone of Melville Island in the Canadian Arctic, but the restricted species generally appear in different beds of unknown stratigraphic relationship (Frebold, 1960, p. 28). *P. mclintocki* was also found within a coquina bed of *Oxytoma jacksoni* (Pomp.) (ident. writer) known to flourish in the *L. opalinum* Zone of Prince Patrick Island and the Arctic slope of Alaska (Frebold, 1957); however, the compressed ammonites figured (Imlay, 1955, pl. 12, figs. 15, 16) do not allow definite subspecific identification, neither is their specific identity certain and the same is true for specimens associated with *Erycitoides howelli* in Alaska and the Yukon. Because *Pseudolioceras*, much resembling *P. mclintocki,* still occurs in the *S. sowerbyi* Zone assemblage of Wide Bay a long range is established for this species. *E.* (*Kialagvikes*) *kialagvikensis* is not yet known from outside southern Alaska.

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[4] A new formal biostratigraphic term for beds containing the *Erycitoides* assemblage, typified by *E. howelli* (White). [The author is not following the Code Strat. Nomen.—same fossil name should not be used for zone and a subdivision of that zone. Ed.]

Erycites imlayi is known by two specimens only from the *E. howelli* zonule of Wide Bay (loc. 48 $A_1=95=21246$). The genus and probably also many of its species are long ranging. *E. fallifax* Arkell [*E. fallax* auct.] of the *L. opalinum* Zone to *L. murchisonae* Zone of Europe appears to be most closely related. *Abbasites platystomus* is closely related to *A. abbas* and *A. aegrotus* Buckman spp., of the upper *L. murchisonae* and *G. concavum* Zones of England, and probably also to a species of the *Pseudotoites-Docidoceras* complex from the *S. sowerbyi* Zone of Wide Bay. Another apparently conspecific specimen comes from near the top of the *E. howelli* Zone ($F21=19755$). *E.* (*Eudptetoceras*) *amplectens,* also known from the *Eudmetoceras* zonule in the Upper *E. howelli* Zone, occurs rather frequently in the "*Eudmetoceras* hemera" of Dorset, at the boundary of *G. concavum* and *S. sowerbyi* Zones, but appears to be restricted to the *G. concavum* Zone on the European continent. Again, a closely related form occurs in the *S. sowerbyi* Zone assemblage of Wide Bay. *Podagrociceras athleticum* Maubeuge and Lambert (1955)[5] from the uppermost Toarcian or Lower Bajocian (Aalenian) of Neuquen, Argentina, closely resembles *Erycitoides (Kialagvikes) kialagvikensis* (White) except for the totally absent keel.

In conclusion, the *E. howelli* zonule of the basal *E. howelli* Zone probably belongs in the late Early Bajocian (late Aalenian) and probably corresponds to the *G. concavum* Zone.

Middle E. howelli Zone, or E. teres-profundus zonule.—The Middle *E. howelli* Zone has yielded abundant *Erycitoides teres* and *E. profundus, spp. nov.,* apparently restricted to this interval at Wide Bay. *E. howelli* and *E. (Kialagvikes) kialagvikensis,* the latter now abundant, *Pseudolioceras mclintocki whiteavesi* and probably *Tmetoceras scissum* also persist into the Upper *E. howelli* Zone. *E. (K.) levis* and the rare *E. (E.?) paucispinosus, spp. nov.,* also may be restricted to this zonule whereas *E. (K.) spinatus sp. nov.* also occurs at least in the Upper *E. howelli* Zone. All these species, obtained from the Short Creek section (A 454, L 1067, F 12 = $48A_1$-86), from the sea cliff west of Anderson Creek (A 85, A 86) and probably the Moose Creek-Mt. Kathleen section (A 7/9), are endemic, except for *T. scissum,* and do not allow inter-continental age correlation.

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[5] Re-described by the author (1964a).

Upper E. howelli Zone incl. Eudmetoceras and T. tenueflexicostatum zonules.—At the base of the Upper *E. howelli* Zone *Erycitoides howelli* again abounds as the only species of the restricted genus. It occurs with moderately frequent *E.* (*Kialagvikes*) *kialagvikensis,* rare *E.* (*K.*) *spinatus,* some *Pseudolioceras mclintocki whiteavesi, Holcophylloceras* cf. *H. ultramontanum* (Zittel), and few *Tmetoceras kirki, sp. nov., T.* (*Tmetoites*) *tenue, subgen, et sp. nov.,* and *T.* (*Tmetoites*) cf. *T. alpinum* (Thalm.) may occur in this interval. *T. kirki* proper may resmble *T. scissum* superficially but is closely related to the other species and subspecies occurring in the Upper *E. howelli* Zone, including the microconchs *T. tenue* and probably *T.* cf. *alpinum. Tmetoceras (Tmetoites) alpinum* was originally described, as *"Helicoceras",* from the "Eisensandstein bei Murren" (probably *L. murchisonae* Zone) in the Swiss Jura Mountains. The other species of *Tmetoceras,* mainly collected at localities A 8 and F 59, are not yet known from outside Wide Bay. *Erycitoides howelli* does not include spinose variants, but fasciculate variants are frequent, in contrast to the occurrence in the *E. howelli* zonule below. *Holcophylloceras ultramontanum* was described from the Lower Bajocian (Aalenian) of Europe, Japan, and Argentina.

The most important ammonite assemblage for dating purposes occurs in the *Eudmetoceras* zonule at Wide Bay *(nom. nov.)* which directly overlies the sea cliff containing the fauna just described at the southwest end of Wide Bay (locs. A 22, F 85). The assemblage includes abundant *Pseudolioceras mclintocki whiteavesi,* rare *Erycitoides* cf. *howelli,* and several species of *Eudmetoceras* have now been identified which were unknown from North America.

One specimen (F 58) resembles *E. eudmetum* Buckm., the type species known from the *"Eudmetoceras* hemera" of the *G. concavum—S. sowerbyi* Zone boundary of Dorset, and is probably identical with the Argentine *"Hammatoceras lotharingicum* Benecke" described by Jaworski (1926a) from the *"Eudmetoceras* beds" (horizon 2 of Cerro Tricolor, and horizon 9 of Arroyo Blanco) and dated by him as "Murchisonae-concava zone" but by Arkell (1956) as lower *S. sowerbyi* Zone, and probably also with *"Harpoceras* aff. *variabile* d'Orb." as described by Gottsche (1878) from the Espinazito Pass, Argentina.

The *"Eudmetoceras* beds" of Argentina directly underlie or are synonymous with the lower *"Sonnina* beds", corresponding to the *S. sowerbyi* Zone, and partly overlie beds with *Tmetoceras* cf. *scissum* and *Graphoceras* sp. The Argentinian species is named *E. eudmetum jaworskii, subsp. nov. E. nucleospinosum, sp. nov.,* known by three specimens from locality A 22, *Eudmetoceras* zonule, is a close relative of *Eudmetoceras gerthi* (Jaw.); *E.* (*Euaptetoceras*) *amplectens* (Buck.) from the same horizon is homeomorph with *"Oppelia" moerickei* Jaworski (1926 a, b), a probable *Strigoceras* from the *"Eudmetoceras* beds" and the *S. sowerbyi* Zone of Argentine and from the same zone of Wide Bay. Another homeomorph is the Argentine *"Harpoceras klimakomphalum* (Vacek)" which appears to morphologically intergrade with the associated supposed *Pleydellia* spp. (Gröber, 1918, Arkell, 1956), i.e. *"Harpoceras" hauthali* and *"H." malarguense* Burckhardt spp. (1903, Pl. 1). The same assemblage from Cerro Puchén (locality "M 7") also includes smaller much more evolute forms, *i.e. "H." puchense, "H striatulum* (Sow.)", and *"Witchellia" argentina* Buckhardt, spp., which may well constitute the corresponding microconchs. Based on the preliminary studies of faunules from Neuquén, the author tentatively suggests that all the named "species" may belong to two or three dimorphic species of a single new genus or subgenus affiliated with *Pleydellia.* The age of the Andean assemblage is probably early Lower Bajocian (early Aalenian); taxonomic and stratigraphic studies are much needed. The obviously inconsistent stratigraphic occurrences of the first three species as reported by Weaver (1931, pp. 25-32 and correlation chart) are almost certainly due to misidentification on the specific and generic levels. Significantly, rare *Eudmetoceras amplectens* and *E.* cf. *eudmetum* have now also been identified in the *S. sowerbyi* Zone of Wide Bay.

Eudmetoceras amplectens also occurs in the *"Eudmetoceras* hemera" of Dorset and in the *G. concavum* Zone on the European continent. The *Eudmetoceras* zonule of Wide Bay appears therefore to be slightly older than at least most of the *"Eudmetoceras* beds" of Mendoza and Neuquén, Argentina, which usually include the first sonniniids abundantly and thus resemble the English occurrences of typical *Eudmetoceras* in the *H. discites* Subzone of the lower *S. sowerbyi* Zone of Dorset. Consideration, however, is to be given to the possibility that this association of *Eudmetoceras s.s.* and *Sonninia* may be due to condensation.

In the upper part of the Upper *E. howelli* Zone, *Erycitoides howelli,* now predominantly with fascilate costation, and *E. (Kialagvikes) kialagvikensis* become abundant again while *E. (K.) spinatus* and, probably, also *E.* (*K.*) *levis, Abbasites platystomus, Partschiceras* cf. *P. gardanun, Holcophylloceras* cf. *H. ultramontanum,* and *Pseudolioceras mclintocki whiteavesi* persist in small to moderate numbers. This is the *"H. ? kialagvikensis* subzone" of Kellum, *et al.,* in which *E. (Kialagvikes)* supposedly is much more frequent than *Erycitoides s.s.* However, the Shell and U.S.G.S. collections contain slightly more specimens of the latter subgenus from the beds of this interval although the frequency difference is probably not significant. At the top this assemblage, the *T. tenue-flexicostatum* zonule, also includes peculiarly fine and partly sigmoidally costate *Tmetoceras* including both dimorphs: the large *T. kirki flexicostatum, sp. et subsp. nov.,* resembles *T. diffalense* (Gemm.) [*T. gemmellaroi* auct.] originally described from the *L. murchisonae* Zone of the Apennines; the "microconch species" *T. (Tmetoites) tenue, subgen. et sp. nov.,* is known only from Wide Bay and Puale Bay; *T.* (*T.*) *sp. nov.* A appears to be identical with *"Tmetoceras* aff. *gemmellaroi* Fucini" described by Burckhardt (1903) from the upper "*Meleagrinella* beds" at Barda Blanca, Argentina, which, at Espinazito, have yielded *Tmetoceras* cf. *T. scissum* and *Graphoceras* cf. *G. concavum.* This is another though weak line of evidence for the very late Early Bajocian (late Aalenian) age of the Upper *E. howelli* Zone.

Comparisons.—Little appears to be known, or at least published, about the Bajocian of eastern Siberia. The lower Bajocian (Aalenian) assemblages, reported but described or figured only to a small degree, are almost totally different in regard to ammonoids, but include the whole species group of *Inoceramus* originally described from the Alaska Peninsula which also abounds in North Alaska and the Canadian Arctic islands (Krimholz, 1939; Eichwald, 1871). An exception is *Pseudolioceras,* which is said to occur in the late Toarcian as well as in the Lower Bajocian; *P. beyrichi* (Schloenb.) was recently reported as characterising the lower Aalenian basal Bajocian of the Lena-Yenisei depression, and the Verkhoyansk foredeep (Sachs and Strelkov, 1961, p. 51, table 1). This occurrence was correlated with the *E. howelli* Zone of Alaska. However, this is a European species, though confirmation cannot be made without its description. In the same areas this assemblage is said to be overlain by beds with *"Ludwigia concava",* also undescribed, accompanied by *Eumorphotis* (*Arctotis*) *lenaensis. L.* (*Graphoceras) concava* supposedly occurs as far east as the Verkhoyansk-Chukchi area though the lower horizon appears to be missing there. However, in the Anadyr-Koryak area, of the east Siberian Sea ammonites were apparently absent during the Middle Jurassic (*loc. cit.*). This also may explain the absence of any appreciable ammonoid migration through the narrow seaway which supposedly connected the Siberian Sea with the south Alaskan geosyncline (see paleogeological maps, *op. cit.).* From the Bureya River basin in the western Amur area, further to the south, Krimholz (1939) described a Lower Bajocian (Aalenian) ammonite assemblage, overlying a 530 m. thick, apparently post-Toarcian, *"Inoceramus* series", which includes *"Lioceras* [*Ludwigia*] cf. *brasili* Buckman", described (p. 28) but not figured, *"Hammatoceras* sp." and also the Alaska Peninsula type *Inoceramus* spp. mentioned above. This assemblage is probably representative of the *L. murchisonae* Zone. The hammatoceratid may belong to *Planammatoceras* which occurs in this zone in Europe, and is common in the whole Tethys area and Japan, but is absent in North America.

Along the western side of the Pacific, related faunas may be expected because of the absence of obvious migration barriers. Sato (1954a and b, 1957, 1958) described and figured the Aalenian ammonite faunas of northern Japan and newly named a number of *"Hammatoceras"* species. These however, appear to be closely related and, in part, identical with the typical Mediterranean *Planammatoceras* assemblage, also known as a numerically minor element from the western European epeiric seas and flourishing in the *L. murchisonae* Zone, such as *P. planinsigne* (Vacek), *P. procerinsigne* (Vacek), and *P. lorteti* (Vacek, *non* Dum., = '*P. vaceki* Roman', *non* Prince, *non* Brasil). Thus there is no relation in the hammatoceratids between the Japanese "*Hammatoceras* zone" and the Alaskan *E. howelli* zone. But the Japanese assemblage resembles the Alaska assemblage in containing abundant *Tmetoceras,* though only *T. scissum* (Ben.) (as "*T. recticostatum" sp. nov.,* Sato, 1954), and almost certainly *Pseudolioceras* (as "*Graphoceras* sp." Sato, 1958, and "? *Hyperlioceras* sp.", 1957), *Holcophylloceras* cf. *H. ultramontanum* (Zittel), and some lytoceratids. These elements are more or less universally distributed, though they may be centered around the Tethyan realm. This Japanese assemblage is tentatively regarded here as slightly older than the Alaskan assemblage and probably equivalent to the *L. murchisonae* Zone, and, approximately to the Alaskan *T. scissum* "zonule." Lower Bajocian (Aalenian) deposits are unknown elsewhere in the western Pacific and, until recently, also in the eastern Tethyan realm (see Arkell, 1956), where Imlay and Sato (see Sato, 1961) identified *Tmetoceras, Ludwigia,* and *Erycites.* Only the latter genus was described (in a single incomplete specimen, *op. cit.).* The most eastern Tethyan rich ammonite assemblage of this age was described from Iran which is already of the condensed Cape San Vigilio type (see Arkell, 1956, p. 381).

No typical ammonoid species of the *E. howelli* Zone is known from Canada (except from the extreme north), the United States or Central America, with the possible exception of "*Tmetoceras* n. sp." and "cf. *T. scissum* (Ben.)" reported but neither described nor figured from the basal Weberg formation in central Oregon. These species are said to be associated with "*Deltostrigites* and sphaeroceratids n. gen., similar to *Emileia*" in their uppermost occurrences (Lupher, 1941). Because the latter forms are of Middle Bajocian age this is probably due to some condensation or reworking, but nevertheless is in support of a late Early Bajocian (late Aalenian) age. The fauna is much (though only partly) related to the assemblage from the "*Eudmetoceras* beds" of Argentina and, surprisingly, also with the "*Eudmetoceras* hemera" of Dorset, almost on the opposite side of the globe, which bears the closest similarity of all known ammonite assemblages to the latter. Both will be further discussed in the specific descriptions.

S. SOWERBYI ZONE

The next youngest fossil assemblage in the Wide Bay area occurs approximately 100 m. above the *T. tenue-flexicostatum*-zonule and has an estimated vertical range of 100-150 m.; the extremely rich and well-preserved fauna contains such universal and circumpacific genera as *Sonnina* (incl. *Euhoploceras, Fissilobiceras* ?), *Witchellia, Eudmetoceras s. s., E.* (*Euaptetoceras*), *Pseudolioceras, Pseudotoites,* (?) *Otoites, Strigoceras, Holcophylloceras,* and *Lytoceras*. The northwest European faunal elements present are typical for several subzones of the *S. sowerbyi* Zone. This assemblage, to be studied next by the writer, should prove of particular importance for age correlation between the "NW-European" (north Atlantic) and circumpacific faunal realms.

FOSSIL LOCALITIES AND AMMONITE FAUNAS

Locality descriptions are only available for the U.S. Geological Survey collections. All localities are accurately plotted in the index map (Text-fig. 2). The number of fossil specimens, if more than one, is given in parentheses. Shell Oil Co. localities prefixed by 'A' and 'B' were collected in 1953; those prefixed by 'L', collected in 1955.

WIDE BAY

Shell Oil Company localities (coll. 1953-1955).—

Field No.	
A 5	Moose Creek-Mt. Kathleen Section, ca. 50 m. below top of Kialagvik formation. *Erycitoides howelli* (White), *E. (Kialagvikes) kialagvikensis* (White).
A 7	Same section, ca. 130 m. below top Kialagvik formation. *Erycitoides* cf. *E. howelli* (White), *E. (Kialagvikes) kialagvikensis* (White) (4).

A 8	Same section, float from 25-30 m. sea cliff ca. 100-130 m. below top Kialagvik formation. *Erycitoides howelli* (White) (≧27), *E.* (*Kialagvikes*) *kialagvikensis* (White) (8), *E. (K.) spinatus, sp. nov.* (2), *Tmetoceras kirki kirki, sp. et subsp. nov., T. (Tmetoites) tenue, sp. nov.* (?) (2), *Pseudolioceras mclintocki whiteavesi* (White) (2), *Holcophylloceras* cf. *H. ultramontanum* (Zittel) (2).
A 9	Same section, same horizon as A 7. *Erycitoides howelli* (White) (>2), *E.* *(Kialagvikes) kialagvikensis* (White), *E. (K.) levis, sp. nov.*
A 10=L543	Same section, ca. 35 m. below top of Kialagvik formation. *Erycitoides howelli* (White) (>15), *E. (Kialagvikes) kialagvikensis* (White) (≧11), *E.* (*K.*) *levis, sp. nov. ?, Pseudolioceras mclintocki whiteavesi* (White), *Partschiceras* cf. *P. gardanum* (Vacek) (3), *Holcophylloceras* cf. *H. ultramontanum* (Zittel) (3).
A 11	Same section, ca. 15 m. below top of Kialagvik formation. *Erycitoides howelli* (White), *E. (Kialagvikes) kialagvikensis* (White) (2), *Pseudolioceras mclintocki whiteavesi* (White), *Tmetoceras kirki flexicostatum, sp. et subsp. nov.* (2), *T. (Tmetoites) sp. nov.*
A 22	Same section, top of sea cliff ca. 95 m. below top of Kialagvik formation. *Erycitoides* cf. *E. howelli* (White), *Eudmetoceras nucleospinosum, sp. nov.* (3), *E. (Euaptetoceras) amplectens* (Buckm.), *Pseudolioceras mclintocki whiteavesi* (White) (11).
A 85	Near shore between Short Creek and Pass Creek, about 250 m. below top of Kialagvik formation. *E. (Kialagvikes) levis, sp. nov.* (4+?2), *E. (K.)* cf. *kialagvikensis* (White), *Praestriaptychus antiquus, sp. nov.*
A 86	3 km. SW of A 85 and about 14 m. lower in section. *Erycitoides profundus, sp. nov.* (>3), *E. teres, sp. nov.* (9), *Phylloceras ?* sp., *Tmetoceras scissum* (Ben.) (?) (2+?1).
A 250	Near shore, 1.8 km. NE of mouth of Des Moines Creek, position uncertain, between about 20 and 100 m. below channeled top of Kialagvik formation. *Tmetoceras (Tmetoites)* cf. *T. alpinum* (Thalmann), *Partschiceras* cf. *P. gardanum* (Vacek).
A 443	Sea cliff 0.5 km. SW of mouth of Pass Creek, about 185 m. below top of Kialagvik formation. *E. (Kialagvikes) kialagvikensis* (White), *Pseudolioceras mclintocki whiteavesi* (White).
A 444	Sea cliff 0.3 km. SW of mouth of Pass Creek, about 180 m. below top of Kialagvik formation. *Erycitoides howelli* (White) (≧13), *Abbasites platystomus, sp. nov., Pseudolioceras mclintocki whiteavesi* (White).
A 446	Sea cliff 1.4 km. SW of mouth of Pass Creek, about 190 m. below top of Kialagvik formation. *Erycitoides howelli* (White) (≧8), *Pseudolioceras mclintocki whiteavesi* (White).
A 447	0.3 km. SW and 15 m. below A 446. *Erycitoides howelli* (White) (≧8), *E. (Kialagvikes) kialagvikensis* (White), *Eudmetoceras* (*Euaptetoceras*) *amplectens* (Buckm.), *Pseudolioceras mclintocki whiteavesi* (White).

A 449	Sea cliff 2.4 km. SW of mouth of Pass Creek, about 220 m. below top of Kialagvik formation. *E. (Kialagvikes) kialagvikensis* (White) ? (2), *Pseudolioceras mclintocki whiteavesi* (White).
A 454	Short Creek section, about 160 m. below top of Kialagvik formation. *Erycitoides profundus, sp. nov., E. paucispinosus, E. teres* (4), *spp. nov., E.* (*Kialagvikes*) *kialagvikensis* (White) (3), *E. (K.) levis, sp. nov.* (2).
A 456=L1042	Same section, about 30 m. below top of Kialagvik formation. *E. (Kialagvikes) levis, sp. nov. ?* (3), *Tmetoceras* sp.
L 154	At shore on south side of Wide Bay 5 km. E. of mouth of Kialagvik Creek, about 60 m. below top of Kialagvik formation. *Tmetoceras kirki flexicostatum sp. et subsp. nov., T.* (*Tmetoites*) cf. *T. tenue, sp. nov.*
L 285	Sea cliff 2.5 km. SW of mouth of Pass Creek, about 245 m. below A 449. *Erycitoides howelli* (White) (≧31), *E., sp. nov.* aff. *E. howelli, Pseudolioceras mclintocki whiteavesi* (White), *Partschiceras gardanum* (Vacek) ?, *Tmetoceras* cf. *T. scissum* (Ben.).
(L 543=A 10)	
L 555	South side of Wide Bay, 2.7 km. E. of mouth of Kialagvik Creek, about 330 m. below top of Kialagvik formation. *Erycitoides howelli* (White).
L 556	0.3 km. SW of L 555 and about 15 m. stratigraphically below. *Erycitoides* cf. *howelli* (White) .
L 1041	Short Creek section, about 16 m. below top of Kialagvik formation. *Erycitoides* cf. *E. howelli* (White).
(L 1042=A 456)	
L 1066	Near Short Creek section, 0.4 km. ENE. of L 1041, about 95 m. below top of Kialagvik formation, *Erycitoides* sp.
L 1067	Near Short Creek section, 0.4 km. NE. of A 456, about 135 m. below top of Kialagvik formation. *Erycitoides howelli* (White) (≧2), *E., sp. nov.* aff. *E. howelli, E. profundus, sp. nov.* (2), *E. paucispinosus, sp. nov.*

U.S. Geological Survey Mesozoic localities (21245-21254 *collected by Ralph W. Imlay and Don J. Miller,* 1948; 19747-19789 *by Lewis B. Kellum,* 1944).—

Field No.	*Catalogue No.*	
F 12 (=$48A_1$—86)	19747 (=21245)	Fourth stream cut on south side of Short Creek, about 1.5 km. above mouth ("about 1050′ below top of Kialagvik formation"). *Erycitoides howelli* (White) (>2), *E. (Kialagvikes) kialagvikensis* (White) (≧10), *E. (K.) spinatus, sp. nov.* (3), *Pseudolioceras mclintocki whiteavesi* (White).

F 13	19748	South side of Short Creek at SW end of the amphitheatre at the first rapids on Short Creek ("800′ below top of Kialagvik formation"). *Erycitoides* ex gr. *E. howelli* (White), *E. (Kialagvikes) levis, sp. nov.* (≧3), *E. (K.) kialagvikensis* (White).
F 21	19755	Stream bed 0.2 km. north of intersection of stream entering Short Creek from the north about 100 m. down stream from the rapids. From a 0.6 m. bed of slabby sandstone which is 8.5 m. below 1 m. sandstone ledge at top of falls ("6.5′ below top of Kialagvik formation"). *E. (Kialagvikes) kialagvikensis* (White), *Abbasites,* sp. juv. aff. *A. platystomus, sp. nov.*
F 23	19757	Float at base of sea cliff between Pass Creek and Short Creek. Collection extends along buffs to the NE of small waterfalls 0.8 km. SW of Pass Creek ("975′ to 880′ below top of Kialagvik formation"). *Erycitoides* cf. *E. howelli* (White).
F 35/36	19766	Sea cliff about 0.4 km. southwest of mouth of Pass Creek ("about 480′ below top of Kialagvik formation"). *Erycitoides howelli* (White) (≧50), *E. (Kialagvikes) kialagvikensis* (White).
F 37	19767	Sea cliffs about 0.2 km. southwest of F 23 and about 23 m. stratigraphically below ("about 1050′ below top of Kialagvik formation"). *E. (Kialagvikes) kialagvikensis* (White).
F 54	19784	Sea cliff behind lagoon 1.6 km. west of mouth of Short Creek; near east end of small waterfall at a prominent ledge opposite tidal flat ("360′ below top of Kialagvik formation"). *Eryccitoides* sp., *E. teres compressus sp. et subsp. nov.*
F 58	19788	Siltstone at top of sea cliffs 0.4 km. southwest of mouth of small Creek (Oso Creek nov.) entering Wide Bay between Anderson and Caribou Creek behind large spit, ("760′ below top of Kialagvik form."). *Erycitoides* sp., *Eudmetoceras* cf. *E. eudmetum jaworskii, subsp. nov., Pseudolioceras* sp.
48 A_1—86 (=F 12)	21245 (=19747)	Outcrop on south side of Short Creek, Grey sandstone bed in dark-grey siltstone sequence ("about 1050′ below top of Kialagvik formation). *Erycitoides teres, sp. nov.* (≧3), *E., sp. nov.* ? aff. *E. teres, E. (Kialagvikes) kialagvikensis* (White).
48 A_1—95	21246	Sea cliff, 0.3 km. along edge of beach southwest of mouth of Pass Creek, from point N. 50° W. of west end of Hartman Island northeastward. Siltstone, sandy siltstone, and sandstone ("about 800′ below top of Kialagvik formation"). *Abbasites platystomus, sp. nov., Erycites imlayi, sp. nov., Erycitoides teres, sp. nov.*

48 A_1—107	21247	First outcrop on north side of Short Creek, about 0.3 km. from beach. Dark-grey siltstone ("about 2,000′ below top of Kialagvik formation"). *Tmetoceras scissum* (Benecke) (≧2).
48 A_1—108	21248	First outcrop on south side of Short Creek, about 0.8 km. from beach WNW of 48 A_1—107. Grey siltstone ("about 1,700′ below top of Kialagvik formation"). *Erycitoides* cf. *E. howelli* (White).
48 A_1—105	21253	Talus at cliff on northwest shore of Wide Bay, 13.5 km. S. 74° W. of west end of Hartman Island (in Shell> section Moose Creek-Mt. Kathleen). Most or all of the fossils are from sandstone exposed at the top of the cliff ("probably about 500′ below the top of the Kialagvik formation"). *Erycitoides howelli* (White) (≧3), *E. (Kialagvikes)* cf. *E. kialagvikensis* (White).
48 A_1—109	21254	Above falls on tributary entering Short Creek about 1.5 km. northwest of the beach. Grey, calcareous sandstone overlying a 0.15 m. conglomerate bed, 1.5—3.0 m. below the top of the sandstone sequence ("about 600′ below top of Kialagvik formation"). *Erycitoides howelli* (White) (~3), *E. (Kialagvikes) kialagvikensis* (White), *E. (K.) spinatus, sp. nov., Pseudolioceras mclintocki whiteavesi* (White), *Tmetoceras kirki flexicostatum, sp. et subsp. nov., T. (Tmetoites) tenue, sp. nov.* (7).
48 A_1—100	21259	Base of sea cliff on northwest side of Wide Bay, 7.3 km. north 10½° E. of west end of Hartman Island (near Shell loc. A 250). From 0.6 m. limestone bed in siltstone, overlain with angular unconformity by conglomerate (of Shelikof formation). ? *Erycitoides* sp.

PUALE BAY, ALASKA PENINSULA, ABOUT 70 KM. NE OF WIDE BAY

Shell loc. B 128: *Pseudolioceras* sp., *Erycitoides* sp., *E. (Kialagvikes)* cf. *E. kialagvikensis* (White), *Tmetoceras (Tmetoites)* cf. *T. tenue, sp. nov.*

SYSTEMATIC DESCRIPTIONS

REPOSITORIES OF TYPES

Specimens collected by the U.S. Geological Survey which become types by description or figuring are deposited in the U.S. National Museum (U.S.N.M.), Washington, D.C.; types collected by Shell Oil Company geologists are to be located in the type collection, University of Washington, Seattle, Wash. (U.W.).

MEASUREMENTS OF AMMONOIDS

With regard to dimensions the usual measurements are taken: diameter in mm. (D), whorl width (W), whorl height (H), and umbilical width (U). The latter three measurements are given in percentage of the diameter at a certain morphogenetic stage. All measurements are made on the internal mold ("steinkern") because the test is rarely preserved. The ornament was registered as the frequency of primary (P) and secondary (S) costae per halfwhorl. Full whorl frequencies would not account sufficiently for morphogenetic changes and these halfwhorls generally coincide with the intervals for dimensional measurements.

TERMINOLOGY OF THE SEPTAL SUTURE

The terminology here applied essentially accords with the terminology applied by Schindewolf (1954 and many other references) and the writer (1956a and earlier). It differs from common current usage (Arkell, 1957, p. 196) in the English-speaking countries in the application of the lobal terms *external* (E) and *internal* (I) as opposed to "ventral (V)" and "dorsal (D)", respectively, and also in being based on the morphogenetical and not morphological principle. This mainly applies to the umbilical lobes (U_1-U_3), partly also called "lateral lobes" in English literature. The usage of external and internal instead of "ventral" and "dorsal" is in consequence of the fact that, in the living *Nautilus pompilius* L., dorsal coincides with posterior ("backwards" against the last septum) and ventral with anterior ("forwards" of the peristome) (Mutvey, 1957, text-fig. 2). Owen in 1860 (see *op. cit.,* p. 228) pointed out that fossil nautiloids may be coiled "upward or downward", *i.e.* forward or backward, and the position of the siphuncle is variable *(op. cit.,* text-fig. 5). This orientation of the body in regard to the shell was recently confirmed on fossil nautiloids based on muscle impressions (Mutvey, 1962); at the same time ammonoids were regarded to be more similarly constructed to the nautiloids than previously supposed (1962a) and probably to be oriented similarly (Mutvey, discussion at Pal. Ges. meeting, Tübingen, 1962) (Westermann, 1964b).

The recent Russian point of view that Mesozoic ammonoids do generally not possess a lateral lobe L (Ruzhencev, 1960) is not discussed here.

Suborder AMMONITINA Hyatt, 1889

Superfamily **HILDOCERATACEAE** Hyatt, 1867

Family **HAMMATOCERATIDAE** Buckman, 1887

Subfamily **HAMMATOCERATINAE** Buckman, 1887

(Including Erycitidae Spath, 1928, and, probably, Podagrosiceratidae Maubeuge and Lambert, 1955)

Genus **ERYCITOIDES** Westermann, gen. nov.

Type species, *Ammonite* (*Lillia*) *howelli* White, 1889.

Genus diagnosis.—Highly evolute planulates, whorl section rounded to subrectangular, minute blunt solid keel, may become obsolete on body chamber; ornament as in *Erycites* with long primaries and more or less projecting secondaries, often fasciculate or with lateral spines or tubercles; septal suture as in *Hammatoceras,* includes macroconchs with simple aperture and microconchs with lappets.

Age and distribution.—Late Lower Bajocian (late Aalenian); Alaska Peninsula, Cook Inlet, Arctic slope of Alaska and Yukon; Kialagvik and basal Tuxedni formations, "Kingak shale."

Remarks and comparison.— *"Am. (Lillia) howelli"* and *"Am. (Lillia) kialagvikensis,"* White sp., were assigned to *Hammatoceras* by Pompeckj (1900), though the second species only tentatively, and to *Erycites* by Imlay (1952, 1955). However, Arkell (1956, p. 538) stated that they are "probably referable to none of these genera," inferring that they belong to a yet undescribed genus.

The genus is morphologically intermediate between *Erycites* Gemmellaro, 1886, which it resembles in the costation, and *Hammatoceras* Hyatt, 1865, which it resembles in the septal suture[6]; the whorl section is more commonly rounded-suboval, as in *Erycites,* than subtriangular, subtrapezoidal or subrectangular, as in *Hammatoceras;* the keel is stronger than in the first but weaker than in the second genus. *Planammatoceras* is distinguished by the much higher and apparently always hollow-floored keel, the generally smooth body chamber and the (always ?) *Hammatoceras*-like nucleus with short or absent primaries. *Eudmetoceras* resembles *Eryci-*

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[6] As a corollary, this may support Arkell's opinion (1957, p. L267) to include the "Erycitidae" Spath, 1928, in the Hammatoceratinae.

toides in the costation of the nucleus but differs in a similar way, though even more strongly. *Breydia* differs in the stronger ornament, is more involute and stout, possesses a stronger keel and a less retracted and simpler septal suture, but it may be the most closely related European form. *Breydia* has been known from the *L. opalinum* Zone of Dorset, but the writer could extend the known range up to the Upper *L. murchisonae* Zone from fieldwork near Beaminster, Dorset (1962). Significantly, this genus also includes a "microconch" species, *i.e. B. newtoni* (Buckman), on which the writer was able to find large lappets (specimen in Geol. Survey Museum, London). The phymatoceratinae differ in the short or absent primaries, the "non-retracted" umbilical lobe, and the large straight "second lateral lobe". This subfamily includes *Phymatoceras* Hyatt, 1867, (syn. *Lillia* Bayle, 1878) to which originally both of the type species were referred.

The generic discrimination from *Erycites,* most closely resembling *Erycitoides* in dimensions and ornament, depends upon the taxonomic significance of the sutural pattern of *Erycites versus* the common pattern of the Hammatoceratinae as presented in *Erycitoides.* These patterns were given family rank by Spath (1928, see footnote). A survey of all described Hammatoceratinae has now established the high significance of the relative size of the external ("ventral") lobe E: all species classified as *Erycites,* because of their blunt or obsolete keel and their long primaries, exhibit an unusually short E, occasionally combined with a reduced E/L-saddle, while all high-keeled species, with solid or with hollow-floored keel, have a large "normal" E and E/L-saddle. Apparent exceptions are *"Erycites" baconicus* and *"E." eximius,* Prinz spp., from the Lower Bajocian of the Bakony Mountains in Hungary, which have the second type suture, typical for hammatoceratids, but according to the original (and only) figures resemble otherwise typical *Erycites* found in the same beds. However, according to current studies of the Bakony material by B. Geczy (priv. comm., 1961), the two named species, and only these, are believed to have originally carried a strong keel as is indicated by conellae on the internal molds, and are consequently referred to *Planammatoceras.*

The large species of the *E. howelli* group, now comprising four species, are usually associated with much smaller species of the *E.*

kialagvikensis group, though the latter ones are mostly less abundant. The phragmocone of the latter group much resembles the inner whorls of the first at comparable size, but correspondance within probable synpatric populations at the species level has been found so far only for the two named species which are the most abundant ones; it is suggested for *E. teres* and *E. levis, spp. nov.*, also found associated. As now known, the large forms had a simple and the small forms a complicated aperture with large lappets. The flexuous shape of the costae on the last whorl of the small species is considered to result from the laterally projected peristome during mature growth finally resulting in the lateral lappets. There can be little doubt that this is another typical case of dimorphism, displaying macro- and microconchs, so commonly observed among Ammonitina (Arkell, 1957, p. L 87; Makowski, 1962, 1963; Callomon, 1963). Few microconchs with lappets have hitherto been known in the hammatoceratids. The lowest possible category is attributed to the microconch and macroconch groups, *i.e.* that of congeneric subgenera.

The often much less abundance of the supposed microconchs such as in the *E. howelli* beds appears to be militate against dimorphism (proportion of 1 : 15). This and the fact that the microconch is unknown from northern Alaska and Yukon where the macroconch occurs can probably be explained with differential postmortem transportation and preservation, as well as with chance and bias towards the large forms during collection of the often rare specimens. Furthermore, ecological factors may be involved.

Subgenus **ERYCITOIDES (ERYCITOIDES)** Westermann, subgen. nov.

Diagnosis.—Large *Erycitoides* with simple aperture.

Age and occurrence.—As for genus.

Erycitoides (Erycitoides) howelli (White), 1889 Pls. 44-58, Text-figs. 6-15

[7]1889. *Ammonites* (*Lillia*) *Howelli,* sp. nov. White (Alaska Peninsula), U.S. Geol. Sur., Bull. 51, p. 68 (498), pl. 12, figs. 1-2, pl. 14, figs. 1-3.

1900. *Hammatoceras Howelli* (White), Pompeckj (Alaska), Russ. K. mineral. Ges., Verh., ser. 2, vol. 38, p. 275.

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[7] White's original collection (U.S.G.S. Mesozoic loc. 20109) includes 17 *E. howelli,* 4(+1) ? *P. ?kialagvikensis,* and 3 *P. mclintocki whiteavesi,* and is the typical association of the *E. howelli* zonule.

1945. *"Hammatoceras" howelli* (White), Kellum, Daviess, and Swinney (Wide Bay anticline), U.S. Geol. Sur., Prelim. Rept., pp. 5, 6, figs. 4A, B.

1952. *Erycites howelli* (White), Imlay (Correl. chart), Geol. Sur. Amer., Bull., vol. 63, p. 978.

(?) 1955. *Erycites howelli* (White), Imlay (north. Alaska), U.S. Geol. Sur., Prof. Pap., 274-D, p. 90, pl. 13, figs. 12, 13.

(?) 1961. *Erycites* cf. *E. howelli* (White), Frebold (Can. Arctic), Geol. Soc. Canada, Bull. 74, p. 7, pl. 5, fig. 2 [already reported, *idem,* 1960, Geo. Soc. Canada, Bull. 59, p. 4].

Lectotype (here).—*"A. (Lillia) Howelli"* White, 1889, pl. 12, figs. 1, 2 [plastotype, here, Pls. 44 & 45, figs. 1a, b]. Well-preserved internal mold, parts of penultimate halfwhorl and peristome absent. Repository: U.S.N.M., 132022.

Locus typicus.—Wide (formerly Kialagvik) Bay, probably sea cliff between mouth of Pass Creek and Short Creek, U.S.G.S. Mesozoic locality 20109.

Stratum typicum.—Kialagvik formation, almost certainly lower part, basal *E. howelli* Zone, *E. howelli* zonule.

Diagnosis.—A large species of *Erycitoides* with shallow wide umbilicus, generally compressed-oval whorl section, rather coarsely and completely costate.

Age.—Late Early Bajocian (late Aalenian), *E. howelli* Zone.

Material.—Approximately 110 specimens from the Shell collection and 60 from the U.S.G.S. collection, from many localities throughout the *E. howelli* Zone of Wide Bay. (Specimen number in parenthesis): A5, A7 (?), A8 ($\geqq$27), A9 ($>$2), A10=L543 ($\geqq$15), A11, A22 (?), A444 ($\geqq$13), A446 ($\geqq$8), A447 ($\geqq$8), A454, L285 ($\geqq$31), L1067, F12, F13 (?), F23 (?), F35=36 ($\sim$50), 48A$_1$—105 ($>$3),—109 ($\sim$3), 20109 (17)[7] (see Text-fig. 5).

Taxonomy and occurrence.—Both of White's "syntypes" apparently came from the same stratigraphical interval as did probably the few other forms originally described from Wide Bay. If so this interval is almost certainly identical with the *E. howelli* zonule in the basal Kialagvik formation yielding highly abundant *E. howelli* [(the lower "'*Hammatoceras*' *howelli* subzone" of Kellum, Daviess, and Swinney (1945)]. The smaller specimen, now a paratype, (Pl. 56, figs. 1-3) is a fully septate inner whorl and is regarded as conspecific with the large lectotype which has a complete body chamber. The relatively coarsely ribbed and tuberculous inner whorls of the paratype intergrade with typically spinose nuclei as well as with finely costate nuclei such as the holotype and subfasciculate forms. All these forms, differing greatly in the ornament and also in the relative dimensions of the inner whorls have to be considered as variants of a single chronodeme.

E. howelli was recorded in similar association from the basal members of the Tuxedni Bay, northeastern Alaska Peninsula (Imlay, 1952, p. 981).

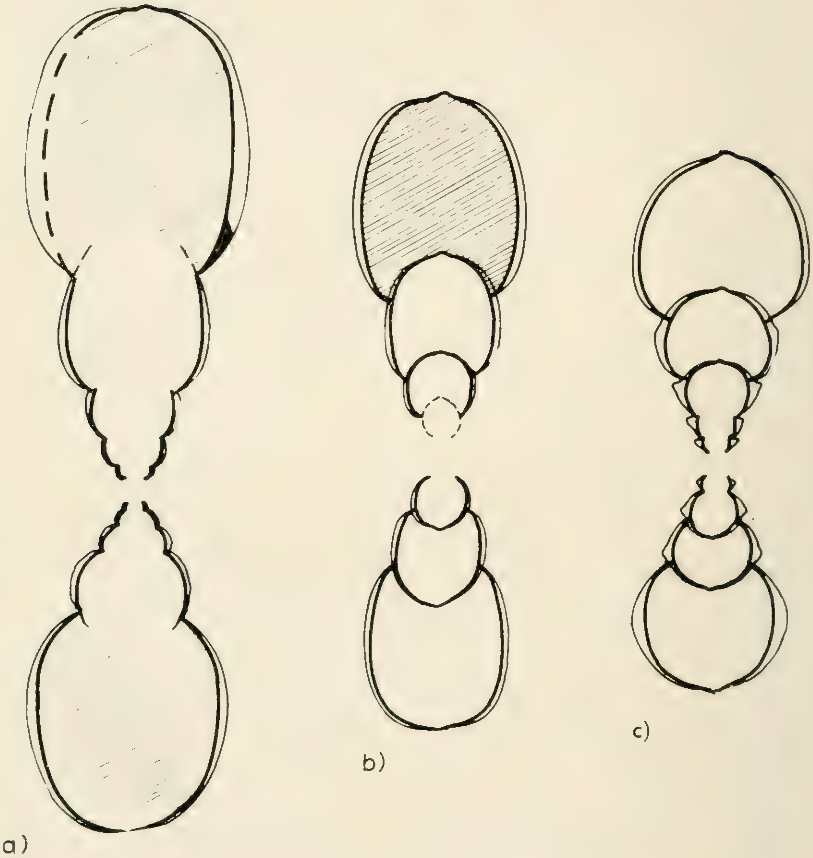
E. howelli also occurs occasionally in the "Kingak shale" of the Lenning and Sadlerochit River Valleys of the Arctic slope of Alaska (Imlay, 1955), associated with *Pseudolioceras* of indeterminable specific identity. *Tmetoceras* sp. was reported in the subsurface of the same area. This suggests the presence of the same faunal association in northern Alaska as on the Alaska Peninsula. The more abundantly occurring *Pseudolioceras mclintocki* (Haughton) is, in the same area, locally associated with a bed of *Oxytoma jacksoni* Pompeckj which is found in similar abundance in the *L. opalinum* Zone of the Canadian Arctic Islands (Frebold, 1957) and may mark a lower horizon in Alaska equivalent to the *L. opalinum* Zone. The same association of *Erycitoides* cf. *E. howelli* and *Pseudolioceras* sp. indet. was recently reported near Bonny Lake in the Richardson Mountains, Yukon Territories (Frebold, 1960, 1961).

Description.—The protoconch is long-ellipsoidal (0.35×0.6 mm.). The first (larval) whorl is strongly depressed; the second whorl grows rapidly, its oval section measures twice as much in width as in height. The siphuncle moves from a central position throughout the first whorl to near the external margin during the second whorl. The third whorl remains broadly ovate but becomes slightly "coronate" by the development of lateral bullae or fine spines, of which there may be seven or eight present per halfwhorl at a width of 2 mm., corresponding to a diameter of 3 mm. Towards the end of the fourth whorl, at about 5 mm. diameter, the whorl section becomes less depressed, now about one and one-half times as broad as high, and low secondaries develop, about 2-3 per primary. There is a smooth external median band already at this early stage. At the same time the septal suture begins to "retract". The ontogeny can be regarded as entering the ephibic stage at this size, after having passed through the neanic (juvenile) stage. The sequence and size interval of growth stages largely resembles the Stephanocerataceae with regard to shape and ornament (Westermann, 1954, 1958).

At a diameter varying from 13 to 20 mm. the whorl section becomes subcircular (W=H=5 to 6 mm.) and during further growth assumes a generally more or less markedly oval shape mostly with some slight trapezoidal trend. The umbilical width increases slightly and gradually, from approximately 30-35% at a diameter between 5 and 10 mm. to a range of 30-40% at 20 mm., and 35-50% during further growth (Text-fig. 8b). However, from 40 mm.D up to the end of the phragmocone the relative umbilical width mostly does not change significantly within a single specimen. Thus there is a great range of intraspecific variation in umbilical width at any one stage. The thickness (relative whorl width) of the conch decreases in average linearly throughout the ephibic stage, from about 50% at 10 mm. D, to 35-40% at 20 mm., to 30-37% at 40 mm., and finally to 26-33% at 80 mm. near the end of the adult phragmocone. The whorl section shows a slightly positive regression up to 80 mm. diameter (H/W=0.9 (0.8)—1.25 at 40 mm.; 1.0—1.35 at 80 mm.), but remains subsequently rather constant in height/width ratio up to the aperture (Text-fig. 8a). Thus again, there is much variation.

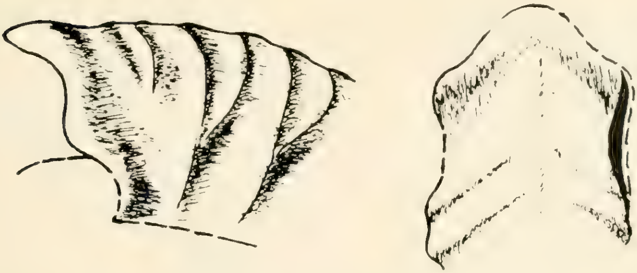
The whorl sides are usually gently rounded up to the umbilical seam, at least up to 30 mm. diameter. Thereafter the sides often become laterally more or less markedly flattened and usually slightly converging, and, consequently, a well-rounded umbilical angle and a narrow umbilical wall may develop which is never steep. More likely is a gradual increase in convexity of the flanks towards the umbilical seam and the umbilicus is typically shallow, large, and smooth.

Between 15 and 20 mm. diameter the keel appears as a low ridge within the smooth siphonal area. Because the keel is partly superficial, *i.e.* largely caused by thickening of the test, there may be hardly any trace at this stage on the internal mold. During further growth the keel usually reaches the thickness and height of the blunt secondaries, at the most semicircular in cross section. The



Text-figs. 6a-c. Cross-sections of *Erycitoides howelli* (White), body chambers hachured. a) Lectotype (Pls. 44, 45), b) another "average" specimen, from loc. A447, c) coarsely costate and spinose variant, from loc. L285 (Pl. 53, fig. 1). All from the Lower *E. howelli* Zone of Wide Bay, X 0.8.

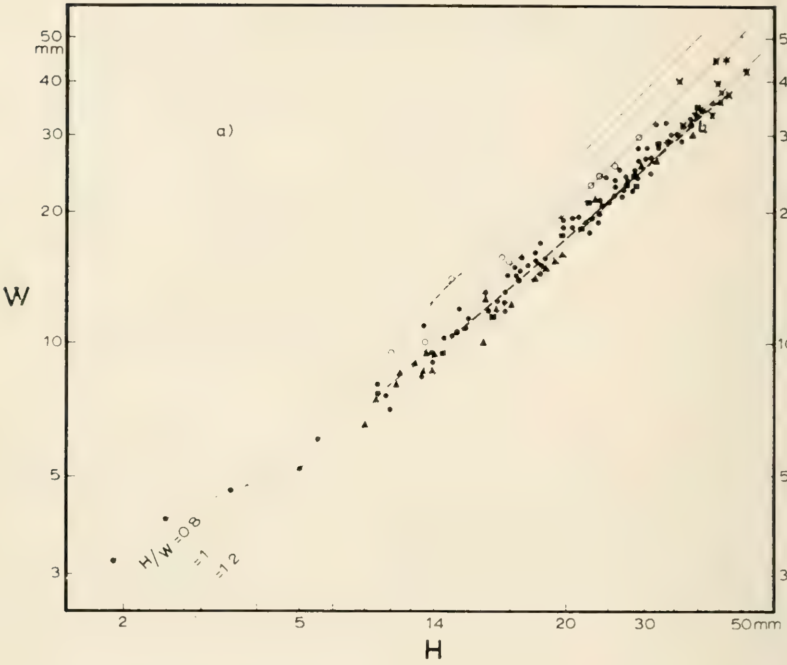
internal mold varies from the near-absence of a keel to a thin, sharp keel comparable to a secondary. The test may be more than twice as thick in the keel than in the rest of the conch, reaching approximately 2 mm. Usually the superficial keel is only rather poorly separated from the external part of the whorl, which may thus occur somewhat fastigate. In the internal mold the keel is



Text-fig. 7. Aperture of *Erycitoides howelli* (White), lateral and extrenal view (Pl. 46). The constriction is mainly owing to thickening of the test partly preserved at the right side. From loc. A444 in the basal *E. howelli* Zone. Wide Bay.

clearly separated from the often slightly tabulate whorl. Beside the keel there remains a broad smooth band on the internal mold which is somewhat reduced on the test.

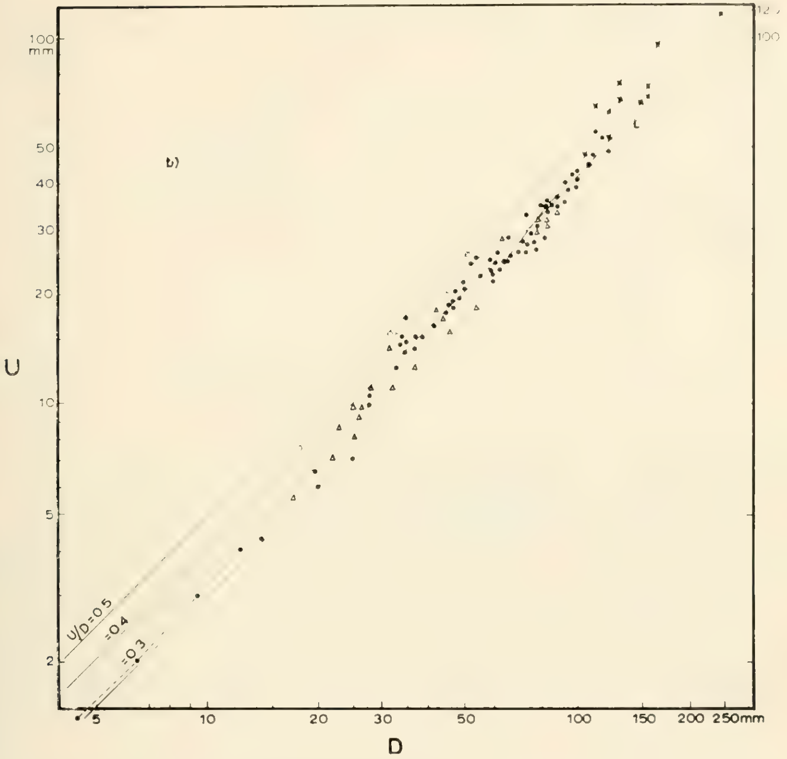
The ornament of the early ephibic whorls is highly variable and only the complete integradation evident from the large sample brought the author finally to the recognition of only a single species (Text-fig. 12). Between about 10 and 40 mm. diameter there may be only 7 to 10 (or 11) strong primaries per halfwhorl (visible in umbilicus) which often rise on the whorl sides to heavy bullae or high spines, or there may be up to 17 only moderately strong or weak primaries per halfwhorl without any bullae, spines, or tubercles, sometimes without clear primary-secondary differentiation, *i.e.* subfasciculate costation. Usually the primaries are rectiradiate or prorsiradiate and terminate on the middle of the flanks. Tubercles or spines are just beside the umbilical seam of the subsequent whorl. Only about 10% of the sample has this coarsely costate, mostly spinate, adolescent stage. The secondaries usually arise by bifurcation, rarely by tri-furcation, and by intercalation. Yet on nearly every fifth specimen there is a trend towards fasciculation: the secondaries may arise on the inner part of the sides from very near a primary. There are 20 to 40 rectiradiate or slightly prorsiradiate secondaries per halfwhorl, their strength varying in reverse to their frequency. They usually project slightly before ending rather abruptly beside the smooth



Text-figs. 8a, b. Scatters for a) whorl height X width and b) diameter X umbilical width of *Erycitoides howelli* (White) from the basal *E. howelli* Zone (circles, open for spinose variants), lower Upper *E. howelli* Zone (triangles) and uppermost (squares) *E. howelli* Zone of Wide Bay. Crossed symbols indicating apertures: many specimens measured at size intervals, some "growth lines" indicated (L=lectotype). The spinose variation has slightly more depressed and evolute whorls (measured intercostally); there is a weak trend from subcircular and moderately involute to slightly compressed and little involute whorls, except for the strongly depressed juvenile whorls (W and H 5 mm.) (see Text-fig. 6). For Text-figure 8b see page 367.

medial zone. The ventral angle enclosed by the secondaries varies from less than 140° to 170°. On the test the smooth zone may be almost missing.

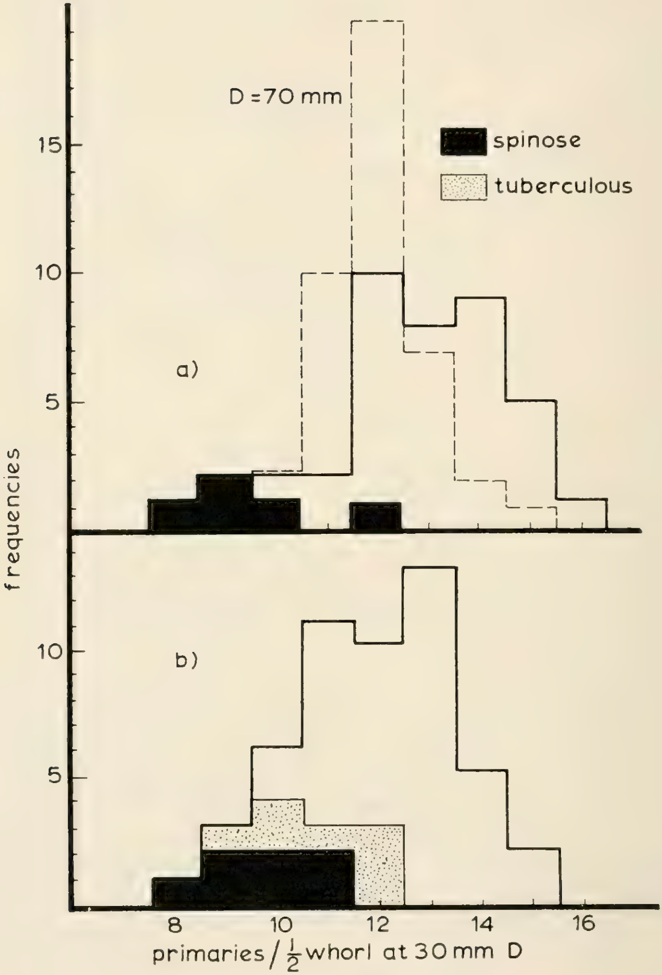
Beyond 40 mm. diameter and up to the aperture lateral spines or tubercles are invariably absent and the costae are less variable in frequency and strength (10-15 prim. half whorl). The primaries are strong, usually extending somewhat to the outer side of the whorl and often markedly bullate. The secondaries do not



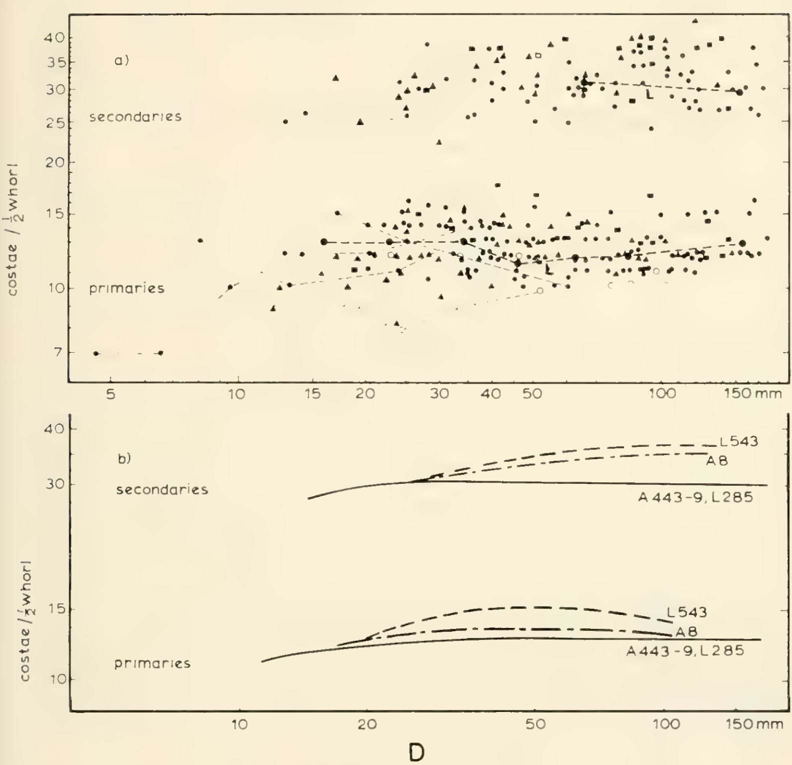
Text-fig. 8b. For explanation see page 366

change significantly in frequency, relative strength and position, and again, they sometimes arise already on the inner flank. The angle between the right and left secondaries varies greatly between 105° and 180°, *i.e.* the secondaries may reach the keel highly acutely or perpendicularly, with the great majority between 65° and 85°. During morphogeny this angle may either remain constant, decrease, or increase (Text-fig. 11). This is significant, because taxonomical significance is often attributed to this inter-costae angle.

The adult body chamber, commencing at approximately 75 to 145 mm. diameter, though mostly between 90 and 110 mm., varies little in length about three-fourths whorl, and reaches a

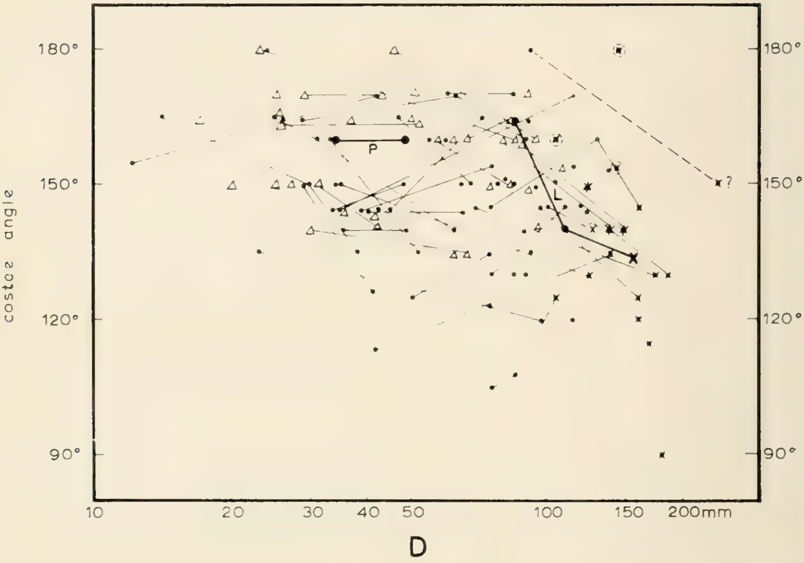


Text-figs. 9a, b. Frequency histograms for primaries/halfwhorl (P) at 30 mm. diameter (thin line at 70 mm.) of *Erycitoides howelli* (White): a) for Shell Oil Company and b) for U.S. Geol. Survey collections; both from Wide Bay. Spines are associated with low frequency and coarse costation, while tubercles take an intermediate position in the essentially unimodal infraspecific variation.



Text-figs. 10a, b. Scatter for costae frequency (P-S)/halfwhorl X diameter (a) and "handdrawn" central lines (b) of *Erycitoides howelli* (White); from the *E. howelli* zonule (circles, open for spinose variants), lower (triangles), and upper Upper *E. howelli* Zone (squares) of Wide Bay. Most specimens measured at half whorl intervals, partly indicated by "growth lines" (L=lectotype). There is a marked infraspecific evolutionary trend to increase frequencies of primaries and secondaries from base to top of the *E. howelli* Zone.

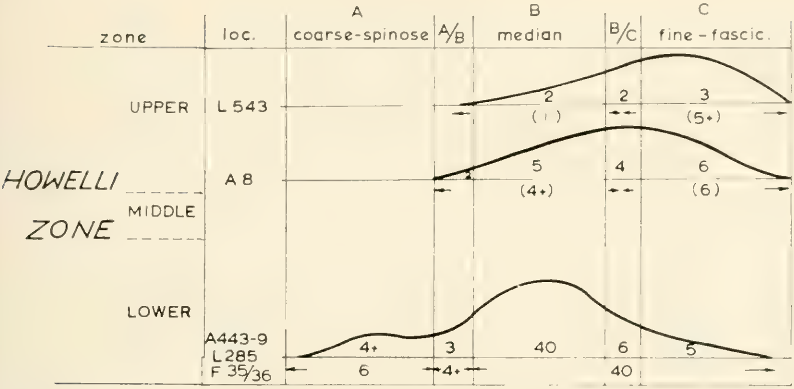
diameter of 120 to 240 mm. with the bulk between 140 and 180 mm. The umbilical width increases at a somewhat higher rate than before, resulting in 40-55% at the aperture, while the rates for whorl height and width decrease. The result is a highly evolute planulate, further emphasized by more marked flattening of the flanks, with more or less slight convergence. This may give rise to or strengthen the development of a distinct umbilical wall. The keel flattens and becomes obsolete on the internal mold. This



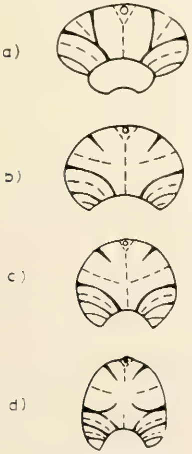
Text-fig. 11. Scatter for costae-angle X diameter of *Erycitoides howelli* (White) from the basal (circles) and Upper (triangles) *E. howelli* Zone. Crossed symbols indicating body chambers, circles apertures. Most specimens measured repeatedly at intervals, all "growth lines" indicated (L=lectotype; P=paratype). The angle between the external terminations of the secondaries shows exceptionally great and irregular variation throughout growth.

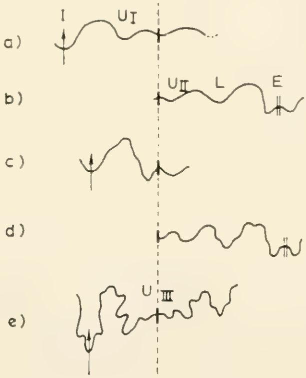
results in a somewhat fastigate or tabulate "venter" and in a whorl section varying from a high oval to a more or less subrectangular or subtrapezoidal shape.

The long primaries and the secondaries usually become increasingly wide and blunt, with a spacing of up to 10 mm. for secondaries, because there is generally little change in costae frequency. In the uppermost part of the *E. howelli* Zone, however, several specimens occur with densely spaced secondaries, which may be subfasciculate, and the primaries may become almost obsolete. They are considered here to be variants of the single species *E. howelli*. The secondaries usually project upwards to the aperture and correspondingly, the inter-costae angle decreases to 90-160°. The body chamber bears 11 to 17 primaries and 26-38 secondaries per half-whorl.



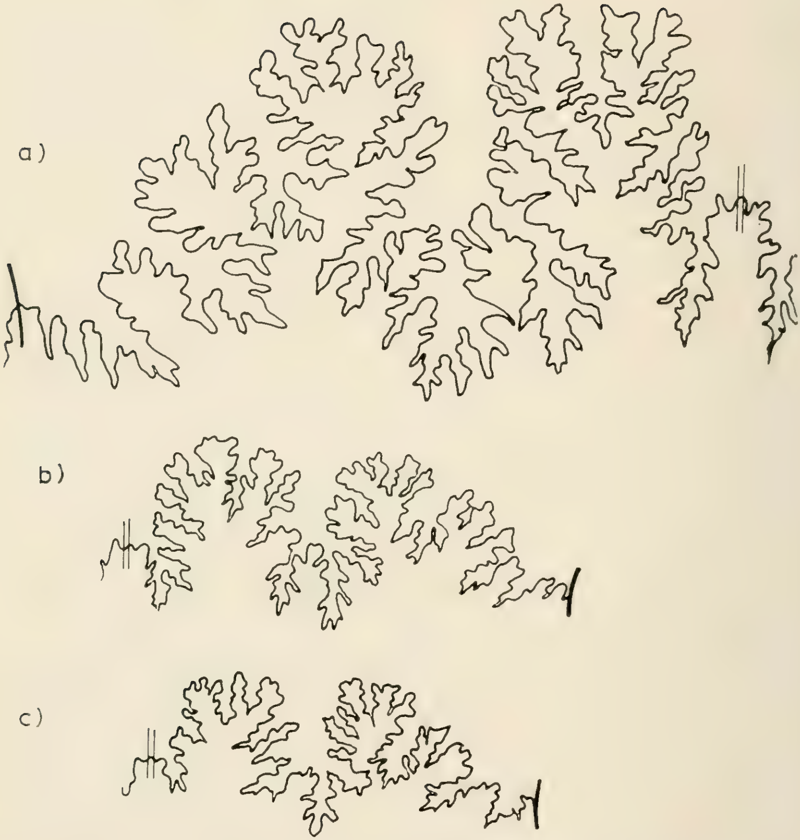
Text-fig. 12. Successive morphotype distribution for *Erycitoides howelli* (White) according to three major costation types with intermediates. Sample sizes indicated of measured well preserved (above lines) and of fragmentary specimens (in parentheses below line) of the Shell lots, and of the U.S. Geol. Survey lots from the *E. howelli* zonule (below line, open.) Typically, spinose variants are restricted to the lowest *E. howelli* Zone, the *E. howelli* zonule, fasciculation becomes dominant in the Upper *E. howelli* Zone. But, because of the remaining intensive overlap of the morphotype groups, no subspecies were distinguished.





Text-figs. 13a-d. Morphogeny of whorl section and septal fluting in *Erycitoides howelli* (White), a specimen from loc. A446 in the *E. howelli* zonule of Wide Bay. At diameters of a) 3.5 mm., b) 9 mm., c) 20 mm., d) 100 mm.; magnifications indicated; solid lines for saddle axes, dashed lines for lobe axes. The first saddle axis corresponding to E/L is incomplete; a somewhat cruciform axial system develops (first whorl not preserved).

Text-figs. 14a-e. Early development of the septal suture in *Erycitoides* cf. *E. howelli* (White), a specimen from loc. A444 in the *E. howelli* zonule of Wide Bay. At diameters of a) 1 mm. (½ whorl), b) 2 mm. (2d whorl), c) 2.5 mm., d) 3.5 mm., e) 5.0 mm.; different magnifications (first sutures missing). The umbilical lobes develop in normal, *i.e.* "orthochron" sequence, U_3 is derived from a saddle and not yet "retracted" at 5 mm. diameter.



Text-figs. 15a-c. Adult septal sutures of *Erycitoides howelli* (White), three specimens from the *E. howelli* zonule of Wide Bay. At diameters of a) about 120 mm. (=46 mm. whorl-height, loc. A444), b) 75 mm. (=28 mm. whorl-height, loc. L285), c) 70 mm. (=23 mm. whorl-height, loc. L285). Internal parts of sutures unknown. U_2 becomes increasingly oblique, U_3 is "retracted" but its original development from a saddle is not totally obscured. All X 1.6.

Preceding the aperture is a broad oblique constriction which is defined on the internal mold. This is due to an internal thickening of the test up to 5 mm. which follows the outline of the peristome. The costation of the internal mold is usually strongly reduced in the constriction but there is apparently no change superficially. This thickened test, presumably for the strengthening of the aperture, is a reliable indicator of the maturity of the shell in the common cases in which the peristome itself is lacking. The simple peristome consists of a "ventral" lappet and moderately sinuous lateral margins which are retracted towards the umbilical seam (Text-fig. 7, Pl. 46).

The development of septum and suture almost certainly commences, as is customary in Jurassic ammonites, by 'orthochrony', *i.e.* the "internal lateral lobe" U_1 is originally present and the umbilical seam lies on the adjoining saddle (Westermann, 1958). The further development of the septal structure resembles most the euflexulate-euflexudisculate patterns of the early perisphincts Leptosphinctinae. It is distinguished, however, by the slight domination of the second instead of the first saddle axis and the correspondingly somewhat larger second (L/U_{11}) than first lateral saddle (E/L) of the suture; their proportions are reversed in the Leptosphinctinae. Finally L/U_2 becomes closely attached to the third lateral saddle (U_2/U_3), poorly separated by U_2 which is reduced to the size and attitude of an accessory lobe (saddle indentation). The external lobe E ("V") is large and deep throughout growth, almost as deep as the lateral lobes. The supposed origin of the umbilical lobe U_3 from a "saddle-splitting" is manifest in its high position only during the neanic stage. At the beginning of the ephibic stage, at a diameter of about 5 mm., the "suspensive lobe" begins to retract, as do the internal umbilical lobes. The adult suture is typified by the "normal" size of E, the high L/U_2 saddle, the strong reduction of U_2 and the strongly retracted U_3, resulting in a V-shaped 'saddle boundary' (Sattelgrenze, Hölder, 1955, p. 59).

At least six specimens associated with large ones are immature forms (locs. A 444, L 285, A 449). The conchs are only between 15 and 65 mm. in diameter and the partly preserved body chambers do not show the usual deviation in shape and costation. Yet the last sutures are insufficiently preserved.

A large specimen of typical *E. howelli* (A 444, pl. 8, figs. 1a, b) displays the pathological abnormality known as 'forma abrupta' (Hölder, 1955, p. 64). Commencing at a diameter of 32 mm. or earlier, and remaining to the aperture at 150 mm., the keel is shifted to the right. On the right flank only primaries are present, while the secondaries of the left flank are extended over the "venter." The costae meet the medial zone perpendicularly and are only slightly projected before the aperture. Yet the septal suture is in almost normal position, with E only slightly shifted in the same direction. The keel coincides with the main accessory lobe of the E/L saddle.

Interrelation of morphological features.—The samples are insufficient for multi-variate statistical analysis of measured morphological features, but some significant trends are evident from the scatter diagrams and frequency polygons (Text-figs. 8-12). The dimensional proportions and the costations of the shell do not vary independently. This is mainly based on a comparison of the highly variable immature growth stages of the large composite sample from the fossiliferous *E. howelli* beds.

A negative correlation between umbilical width and height/width ratio of the whorl is, of course, expected because whorl height is part of the diameter. Similarly, common sense can comprehend certain features of the costation, such as the usual combination of well-defined bifurcation with high strength differentiation between primaries and secondaries and of subfasciculate irregularly branching costae with little difference in strength; or the often occurrence of nodes, tubercles or spines on the summit of primaries, here the point of furcation, when they are strongest developed, *i.e.* at lowest frequency. These observations may give us valuable hints towards the origin and growth control of costae. More surprising is the positive correlation of costae strength with the relative umbilical width ($U/D+100$) and the corresponding negative correlation with the whorl height. Thus the coarsely costate, often spinate forms (morphotype A, Text-fig. 12) have extremely evolute whorls with well-rounded, subcircular-ovoid sections (measured between the costae), while the relatively finely costate average forms (morphotype B) are less evolute, with slightly compressed whorl section, and somewhat flattened sides. This correlation is consistent with the assumption that only a single species, a chronodeme, is present in the sample which includes the coarsely costate variants. No explanation for this correlation is yet suggested.

Morphological trends.—Throughout the 300-350 m. thick *E. howelli* Zone an intra-specific trend is established towards more

Measurements of figured specimens

		D mm.	W%	H%	U%	P	S	Costae-angle	Costae-type*
Lectotype	(aperture)	152	24.3	31	43	13	30	135	s
	(body ch.)	110	29	34.5	40	—	—	140	s
	(phragm.)	ca.64	—	—	ca.38.5	12	ca.31	165	s
Paratype	(phragm.)	48	29	31	40.5	13/14	31	160	s
	"	34	31	34	42.5	12	ca.29	160	s/n
	"	ca.25	—	—	ca.37	10/11	—	—	n
Pl. 46	(aperture)	160	ca.21	ca.28	42.5	12	26	125	s
	(body ch.)	98	25.5	33	39	11	ca.27	145	s
	"	ca.38	—	—	ca.40	14	—	—	s
Pl. 47	(near ap.)	160	ca.23	ca.29	44	15	38	ca.145	s
	(phragm.)	130	ca.27	ca.35	40	—	—	—	s
	"	65	32	37	38.5	10/11	30	145	s
Pl. 48, fig. 2	(body ch.)	124	ca.26	32	42	12	33	ca.140	s
	(phragm.)	100	28	32	40	11	ca.33	145	s
	"	38	31.5	34	ca.40	14	32	145	s
Pl. 48, fig. 3	(phragm.)	90	26.5	34.5	39	13	38	160	s
	"	46	31.5	39	39	12	—	—	s
	"	28	32	36	—	16	ca.36	165	s/f
Pl. 48, fig. 4	(phragm.)	62	32	36	39	12	ca.29	140	s
	"	33	39.5	39.5	39	13	—	—	s/f
	"	25	37	36	38	ca.11	26	165	f
Pl. 50	(near ap.)	165	26	31	45	16	ca.34	ca.130	s
	(phragm.)	100	32	33	38	15	ca.36	—	s
	"	70	31.5	36	36.5	13	ca.33	145	s/f
Pl. 51, fig. 1	(body ch.)	ca.145	25.5	27.5	—	ca.14	ca.30	ca.180	s(path.)
	(phragm.)	95	29.5	31.5	41	11	ca.30	—	s(path.)
Pl. 51, fig. 2	(phragm.)	50	32	34	41	13	ca.31	ca.145	s
	"	34	31	34	44	ca.15	—	150	f

Measurements of figured specimens

		D mm.	W%	H%	U%	P	S	Costae-angle	Costae-type*
Pl. 51, fig. 3	(phragm.)	66	ca.30	38	36	12	29	150	s
	"	37	34	40.5	38	12	—	—	s
	"	ca.18	—	—	—	—	—	—	s/f
Pl. 52, fig. 2	(phragm.)	ca.24	ca.33	ca.31.5	ca.52	8/9	21	180	sp
	"	18	39	33	42	9	—	—	—
Pl. 52, fig. 4	(phragm.)	ca.42	ca.30	ca.36	—	ca.12	ca.33	170	s
	"	12.5	41.5	40	34	11	—	155	s
Pl. 52, fig. 5	(phragm.)	52	30	29	49	10	ca.26	ca.135	s/sp
	"	33	30	28.5	48	9	ca.22	160	sp
	"	23	—	—	ca.48	8	—	—	sp.
	"	14.5	—	—	ca.35	9	—	—	sp
Pl. 53, fig. 1	(phragm.)	98	30.5	30.5	47	11	27	120	s
	"	46	35	32	43.5	12	—	—	sp
	"	23	41	35	48	12	ca.25	135	sp
Pl. 55, fig. 1	(body ch.)	ca.100	—	—	—	ca.13	ca.33	—	—
	(phragm.)	66	32	34	41.5	14	ca.32	135	s
	"	43	29	30	39	14	—	—	s/n
Pl. 55, fig. 2	(phragm.)	37	32.5	40.5	34	12	34	165	f
	"	22	36	37.5	32	11	—	—	f/s/n
Pl. 55, fig. 3	(phragm.)	80	—	ca.33	39	12	35	ca.150	s
	"	24	—	—	—	ca.11	—	—	f
Pl. 55, fig. 4	(phragm.)	86	—	ca.35	ca.37	13	39	ca.160	s
	"	60	—	—	—	15	ca.35	ca.160	s/f
Pl. 56, fig. 2	(phragm.)	25	34	34	39	13	27	170	f/s
fig. 3	(phragm.)	25	36	36	32	16	ca.30	150	s/f
fig. 4	"	17	38	41	32	12	32	ca.165	f
fig. 5	"	51	31.5	38	35	13	32	165	s/f

*s: simple clear furcation, f: fasciculate, n: lateral nodes or tubercles, sp: lateral spines.

finely costate forms. However, this trend occurs by shifting the wide range of morphological variation present in every larger sample, representing a chronodeme, similar to that recently presented by Silberling (1962, pp. 155, 159) on *Ceratitina.* This results in the transgression of the original range for costae density (or frequency) mainly of the secondaries, the omittance of the extremely coarsely plicate and mostly spinose variants, and in the dextral shift of the mode which still, however lies well within the original range. Thus an approximate overlap of 50% in gross morphology exists between the oldest and the later and latest chronodemes which, after several attempts by the author towards taxonomical differentiation, are now considered to be conspecific and consubspecific (Text-fig. 12).

Erycitoides (Erycitoides?) sp. nov.?, aff. **E. howelli** (White), juv.

Pl. 54, figs. 3, 4

Two small, well-preserved specimens with halfwhorl fragments of body chambers as internal molds, from Shell locality L 1067, *E. teres-profundus* zonule (Middle *E. howelli* Zone), Wide Bay (Pl. 54, figs. 3a, b). This is possibly an adolescent coarsely costate and spinate variant of *Erycitoides howelli,* although the whorls are more evolute and the lateral spines stronger. The last septal sutures do not appear to be approximated. The secondaries are much stronger and more projected, though mainly on the phragmocone. The medial smooth zone is broader and the body chamber more depressed than in *E. paucispinosus, sp. nov.*

An extremely small, well-preserved specimen with three-fourths whorl incomplete body chamber, from Shell locality L 285, *E. howelli* zonule (basal *E. howelli* Zone), Kialagvik formation, Wide Bay (Pl. 54, figs. 4a, b). This specimen resembles the specimens above except for the smaller size and may possibly be another adolescent. The secondaries are strongly projected only up to the beginning of the body chamber where they become straight and rectiradiate, though they are slightly projected again near the end.

Measurements.—

	D mm.	W%	H%	U%	P	S
(a) (body ch.)	40	36	31	45	8-9	23
(end phr.)	30	37	33	43	7-8	20
(b) (body ch.)	24	33	31	44	8-9	21
"	18	39	33	42	8-9	20

Erycitoides (Erycitoides) profundus Westermann, sp. nov.
Pl. 58, fig. 2; Pl. 59, figs. 1-3; Pl. 60, fig. 1; Text-figs. 16a, b

Holotype.—Pl. 59, figs. 1a, b; a fully septate internal mold, nucleus missing, partly corroded. Repository: U. W., 16606.

Locus typicus.—Shell locality L1067, Lower Short Creek, Wide Bay, Alaska Peninsula.

Stratum typicum.—Middle *E. howelli* Zone, Kialagvik formation.

Age.—Late Early Bajocian (late Aalenian), *E. teres-profundus* zonule.

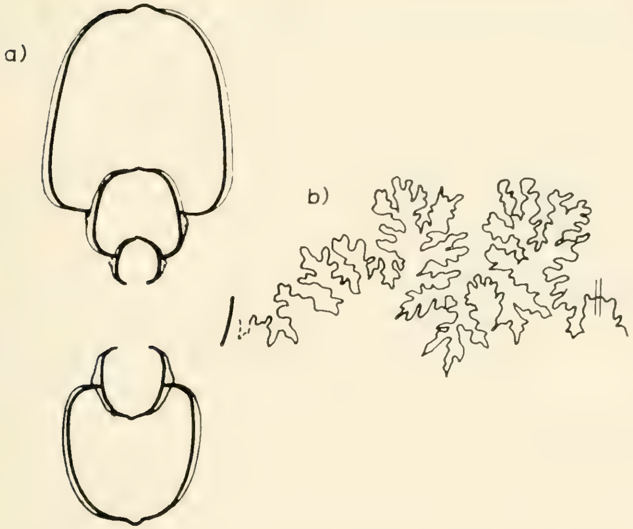
Diagnosis.—A large species of *Erycitoides s.s.,* umbilicus small and deep, steep umbilical walls, coarsely costate.

Material.—2 (+fragments) from L1067, 1 (+) fragment from A454, 3 (+ poor fragments) from A86. All from the Middle *E. howelli* Zone of Wide Bay.

Description.—A distinct umbilical wall develops at a diameter of 20-30 mm. which meets the umbilical seam perpendicularly or, in maturity, often with marked overhang. The largest width of the whorls is near the rounded umbilical margin. The externside ("venter") becomes more acutely rounded at maturity than in *E. howelli* and the keel more prominent. The whorl section is more or less markedly subtrapezoidal during adolescence and rounded subtriangular during maturity. The moderate umbilical width of the nucleus (34-36%) generally decreases slightly on the penultimate whorl. The umbilicus, therefore, appears much deeper throughout ontogeny than in *E. howelli.*

The costation is intermediate in character between *E.* (*s.s.*?) *paucispinosus* and *E. howelli.* There are only 8-11 strong primaries carrying strong lateral spines on the nucleus. The spines become obsolete already at a diameter of approximately 30 mm. Strong secondaries arise by clear bifurcation or lateral intercalation in a frequency of more often three than two per primary. The costae are typically straight and slightly prorsiradiate up to the immediate vicinity of the keel. There is only a narrow medial smooth zone, almost obliterated on the test.

The phragmocone grows to a diameter of more than 160 mm.,



Text-figs. 16a, b. Cross-section (X 0.6) and septal suture (X 1.4 at D=65 mm.) of *Erycitoides profundus, sp. nov.;* holotype, totally septate, from loc. L1067 in the Middle *E. howelli* Zone of Wide Bay (Pl. 59, fig. 1).

and the largest fragment of a body chamber measures 70 mm. in height and width at the aperture, corresponding to a diameter of the conch of approximately 220 mm. Body chambers are poorly preserved (mainly locality A 86). The secondaries increase in frequency (36-38) more than the primaries (12-13) so that there are regularly three secondaries per primary. The secondaries are more narrowly spaced than in *E. howelli,* and project increasingly though moderately, decreasing the intercostae angle to 130°-150°. The ventral smooth zone remains narrow. The keel becomes obsolete only near the aperture.

The left half of an aperture with peristome is well preserved on an internal mold of a fragmentary body chamber probably belonging to this species (Pl. 60, fig. 1). The strong oblique constriction cuts off three secondaries under an angle of approximately 45°. The peristome is sinuous with a broad "ventral" lappet and retraction as in *E. howelli.*

The suture resembles that of *E. howelli* but appears to be somewhat more intensely frilled.

Measurements.—

	D mm.	W%	H%	U%	P	S	Costae-angle
Holotype (phragm.)	106	34	39	34	13	ca.36	150
Pl. 57, fig. 2 (begin, of body ch.)	ca.115	ca.36	ca.42	ca.37	ca.11	ca.43	150
Pl. 58, fig. 2 (phragm.)	73	34	41	32	13	36	135
Pl. 58, fig. 3 (phragm.)	44	36	38.5	35	11	29	160
"	36	—	—	34	10/11	ca.26	ca.165

Erycitoides (Erycitoides) teres Westermann, sp. nov.
Pl. 60, figs. 2-6; Pl. 61, figs. 1-3; Text-fig. 17

Holotype.—Pl. 60, figs. 5a, b; incomplete, fully septate, slightly laterally compressed specimen, nucleus missing, two inner whorls with test, fragment of late whorl as internal mold. Repository: U. W., 16612.

Locus typicus.—Shell locality A 454, lower Short Creek Valley, Wide Bay, Alaska Peninsula.

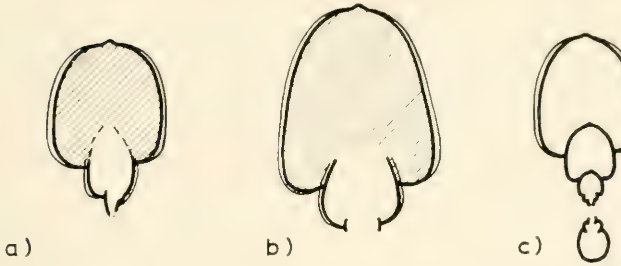
Stratum typicum.—(Lower) Middle *E. howelli* Zone, Kialagvik formation.

Diagnosis.—A small (?) species of *Erycitoides s.s.* with steep umbilical wall, greatly reduced primaries and densely spaced fine secondaries.

Age.—Late Early Bajocian (late Aalenian), Middle *E. howelli* Zone, *E. teres-profundus* zonule.

Material.—Holotype and three small fragmentary specimens from A 454; fragments of three mature specimens from 48 A_1-86 (21245) (=F 12), near or identical to A 454; six (+3) fragmentary specimens from A 86. All from Middle *E. howelli* Zone of Wide Bay.

Description.—The early ephibic stage is observed on three small specimens associated with the holotype which are almost cer-



Text-figs. 17a-c. Cross-sections of *Erycitoides teres, sp. nov.;* a) holotype, body chamber and preceding fragment of phragmocone post-mortem compressed, loc. A454; b) body chamber and slightly deformed phragmocone, loc. A86; c) *E. teres compressus, subsp. nov.,* holotype, wholly septate, loc. A22. a) and b) from the Middle, c) from the Upper *E. howelli* Zone of Wide Bay. All X 0.75.

tainly adolescents of this species. At 12 mm. diameter the inner flanks carry a large number of fine somewhat irregular costae believed to include primaries and extended secondaries. Between 20 and 30 mm. diameter the whorl section is well rounded and probably subcircular. Densely spaced fine sigmoid secondaries (ca. 30/halfwhorl) extend irregularly onto the inner flanks as intercalatories or fasciculately join the similarly weak primaries. The subsequent whorls show only low broad undulations on the inner flanks. Thus the inner flanks visible in the umbilicus regularly become more or less nearly smooth at 25-35 mm. D. If obscure primaries remain there are approximately 12-15 per halfwhorl. Simultaneously the secondaries straighten out and a steep finally "overhanging" umbilical wall develops the more compressed whorl section. The relatively prominent keel is accompanied by narrow smooth zones. The mature phragmocone has about 40-45 extremely densely spaced blunt straight secondaries per half whorl which are slightly prorsiradiate and enclose an angle of 145-160°. No projection has been observed on the phragmocone.

The body chamber is unknown.

The septal suture, as preserved on the holotype, resembles *E. profundus.* It is more intensely frilled than in *E. howelli* and is shorter.

Comparison.—Because of the resemblances in shape and suture this species is believed to be nearest related to *E. profundus* with which it is associated. Though *E. teres* is clearly distinguished in the much finer costation and the reduced primaries of adolescents and matures, *E. howelli* differs similarly and also in the more oval whorl section.

Measurements.—

	D mm.	W%	H%	U%
Holotype (phragm.)	80	35	42	30—35
"	ca.39	ca.37	ca.43	—

Erycitoides (Erycitoides) teres compressus Westermann, sp. et. subsp. nov Pl. 61, fig. 4; Text-fig. 17c

Holotype.—Pl. 61, figs. 4a-f; a well-preserved though incomplete phragmocone as internal mold (coll. Imlay, 1948). Repository: U.S.N.M., 13228.

Locus typicus.—U.S.G.S. Mesozoic locality F 54 (19784), Sea Cliff 1 km. west of mouth of Short Creek, Wide Bay, Alaska Peninsula.

Stratum typicum.—Probably Upper *E. howelli* Zone.

Age.—Late Early Bajocian (late Aalenian), *E. howelli* Zone.

Material.—Holotype only.

Diagnosis.—A strongly compressed subspecies of *E. teres* with primaries obsolescent throughout adolescence and maturity.

Description.—The well-preserved nucleus shows subcircular whorl section at 12 mm. diameter. Subsequently the whorls become increasingly compressed; the sides become flattened parallel to one another; a narrow steep, rounded umbilical wall develops, while the externside becomes more and more somewhat narrowly rounded. The flanks converge only slightly against the end. The umbilicus remains relatively narrow. The keel becomes prominent against the end of the preserved phragmocone, and the adjoining smooth zones are consequently more and more reduced.

The costation of the late neanic and early ephibic whorls consist of widely spaced but weak slightly nodose primaries and extremely fine straight and rectiradiate secondaries. Between 12 and 20 mm. diameter the primaries are obsolescent. The inner flank remains smooth or carries only irregular blunt ribs or bullae corresponding to slight fasciculation of extended fine secondaries. The adolescent and mature secondaries are densely spaced, approximately 40 per halfwhorl, markedly prorsiradiate and somewhat projected.

Body chamber and aperture are unknown. According to the size (approximately 85 mm. complete) and probably also to the straight costae this specimen belongs to *Erycitoides.* The septal suture is highly complex. E is unusually short for this genus, about two-thirds of the length of L. The "second lateral lobe" U_2 is relatively large and only slightly oblique. The umbilical lobe U_3 is large and moderately retracted.

Comparison.—This subspecies resembles *E. teres s.s.* in the costation except for the probably even more reduced primaries; it differs in the more compressed whorl section with consequently almost parallel flanks and much narrower umbilical wall, and probably also in the somewhat narrower umbilicus.

This form is reminiscent of *Erycites leptoplocum* (Vacek) from which it is distinguished in the wider spaced and more reduced primaries, in the more prominent keel, and in the longer external lobe. Another homeomorph is *Planammatoceras tenerum* (Vacek), which, however, has a high hollow-floored keel and a deeper external lobe. There is no doubt that this form belongs to *Erycitoides* and that similar shapes and costations have evolved independently in the different genera.

Measurements of holotype (phragmocone).—

D mm.	W%	H%	U%	P	S
62	31	41.5	31	—	42
45	31	43	32		
27	35	41	32.5	—	ca.32
17	41	44	32.5	ca.10	ca.30

Erycitoides (Erycitoides?) sp. nov. ? (juv.), aff. **E. teres,** sp. nov.

Pl. 61, figs. 5a, b

A single small internal mold with test at umbilicus, U.S.G.S. Mesozoic locality $48A_1$-86 (21245=F 12), Middle *E. howelli* Zone of Wide Bay.

The specimen has a diameter of only 36 mm. at the end of the 1 whorl body chamber, though the aperture is missing. The approximated last septal sutures and the slight egression of the body chamber suggest maturity. According to the straightness of the costae, up to the end of the preserved body chamber, the aperture was almost certainly simple.

The last whorl of the phragmocone, ceasing at 20 mm. diameter, is moderately evolute and subcircular-subquadrate in section. The whorl sides are slightly flattened and slope rather gently but increasingly steeply towards the umbilical seam situated on the middle of the preceding whorl and in contact with its lateral tubercles. The long body chamber becomes gradually much higher and compressed developing a markedly subtriangular section with steep though rounded umbilical well and converging flanks. The externside becomes narrowly rounded. The solid keel is relatively sharp and prominent and accompanied by only narrow smooth zones.

The costation consists of distantly placed blunt primaries, bearing lateral tubercles on the nucleus, and becoming irregular, somewhat bullae-like and ventrally extended on the body chamber. The umbilical slope is almost smooth. The moderately strong secondaries are born by irregular bifurcation, and by fasciculation and weak intercalation on the inner flanks. The costation of the body chamber is rectiradiate and straight except for some slight projection.

The septal suture is only known on the inner flanks. It is here simple and strongly "retracted" and agrees well with the suture of other *Erycitoides* species at equivalent size.

Comparison.—This species appears to be much smaller than any described species of *Erycitoides s.s.* It resembles otherwise most *E. teres, sp. nov.,* in the narrow umbilicus, the development of an umbilical wall, the reduction of the primaries and the prominent keel with narrow smooth zones. However, the adolescent stage of *E. teres* is insufficiently known. This species is more evolute and has weaker primaries than other species of the subgenus.

Measurements on body chamber.—

D mm.	W%	H%	U%	P	S
36	33	42	34	10-12	31
22	34	34	32	11-12	—

Erycitoides (Erycitoides ?) paucispinosus Westermann, sp. nov.
Pl. 54, figs. 5, 6

Holotype.—Pl. 54, figs. 5a, b; partly compressed and slightly exfoliated internal mold, neanic whorls and parts of body chamber missing. Repository: U.W., 16587.

Locus typicus.—Shell locality A 454, Short Creek valley, approximately 1.5 miles upstream, Wide Bay, Alaska Peninsula.

Stratum typicum.—Middle *E. howelli* Zone, *E. teres-profundus* zonule, Kialagvik formation.

Age.—Late Early Bajocian (late Aalenian), *E. howelli* Zone.

Material.—The holotype, and a small internal mold with one halfwhorl body chamber, right side strongly corroded, from loc. L 1067; both from the Middle *E. howelli* Zone.

Diagnosis.—A small species of *Erycitoides (s.s. ?)* with moderately strong densely spaced costae and few well-defined strong lateral spines.

Description.—Both specimens are small, highly evolute planulates, the phragmocones terminating at 22 and 24 mm. diameter, respectively. The umbilicus is shallow and almost smooth. The whorl sides slope gently towards the umbilical seam. The last whorl of the phragmocone is subcircular in section and embraces the preceding whorl almost up to the lateral spines. The body chamber is one whole whorl long on the holotype which at the end only shows indications of approaching the aperture. Traces of the umbilical seam indicate a similar length for the body chamber of the second specimen. The body chamber egresses gradually, finally becoming advolute and slightly compressed oval. The relatively strong solid keel, well separated from the evenly rounded externside, is present at least on the last halfwhorl of the phragmocone and on the whole body chamber.

The earliest observed whorl, at the beginning of the ephibic stage and the penultimate whorl of the phragmocone display only five lateral tubercles per halfwhorl ceasing at about 8 mm. diameter. They are only moderately strong on the holotype but may be called spines on the paratype. On the ultimate one and one-half whorls of the phragmocone there are distantly spaced blunt primaries gradually increasing in strength and irregularly on the holotype. Most primaries have lateral spines and bifurcate and trifurcate into blunt moderately strong and rather densely spaced secondaries. The primaries and secondaries are straight and rectiradiate and leave only a narrow smooth band beside the relatively strong keel which markedly protrudes above the costae. On the long body chamber the primaries become more irregular in strength and flatter towards the umbilical seam, and only 5-8 spinous primaries per halfwhorl remain near the middle of the whorls. Almost completely faded primaries may be visible in the wide interspaces. The secondaries are densely and similarly spaced up to the end of the body chamber. Primaries and secondaries remain essentially straight and the primaries become only slightly prorsiradiate and the secondaries somewhat projected. There are 26 to 30 secondaries per halfwhorl, born by bi- and tri-furcation. Others apparently intercalate on the inner flanks but probably belong mostly to and partly consist of faded primaries. The smooth band beside the keel widens markedly.

A small part of the aperture with shallow faint constriction and possibly the peristome appear to be preserved, though poorly, on the left of the holotype. Because of the absence of rursiradiate costation the aperture was probably simple. Also, the body chamber of *E. (Kialagvikes)* is always highly compressed and laterally flattened but subcircular on this specimen.

The septal suture is exactly as in *Erycitoides* of comparable size.

Comparison.—*Erycitoides paucispinosus* resembles most adolescents of coarsely costate and spinate *E. howelli,* though it is distinguished in the more densely spaced rectiradiate secondaries, the stronger and more irregularly reduced primaries and the more prominent keel accompanied by narrower smooth zones. It is also strongly reminiscent of *Planammatoceras* (?) *diadematoides* (Mayer) and related evolute, coarsely costate and spinose forms, such as *P. rugatum* (Buckman), *P. lorteti* (Dumortier), *P. fossai* (Merla), *P. ? buxtorfi* (Renz), and *P. dolium* (Buckman). This species group is similar in age but clearly distinguished (so far as known) in the high and hollow-floored keel. The only described spinate *Erycites* is *E. robustus* Merla from the Toarcian of Italy which possesses a typical *Erycites* suture. There is no serious doubt that these similarities are due to convergence and that *E. paucispinosus* is closest related, and probably a phyletic derivative of *E. howelli.*

Measurements.—

	D mm.	H%	W%	U%	P	S
Holotype (body ch.)	ca.38	ca.35	ca.32	ca.50	—	ca.32
	ca.24	ca.34	ca.34	ca.40	6	ca.30
Paratype (body ch.)	32	33	35	45.5	7-8	26

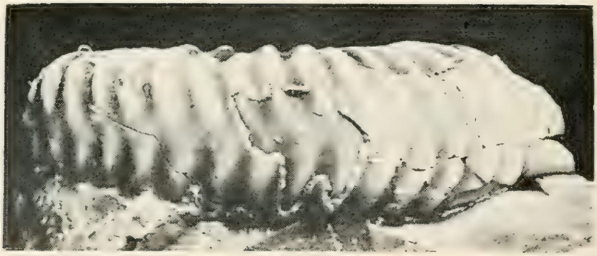
Aptychus of *Erycitoides s.s.*

"Genus" **PRAESTRIAPTYCHUS** Trauth, 1927

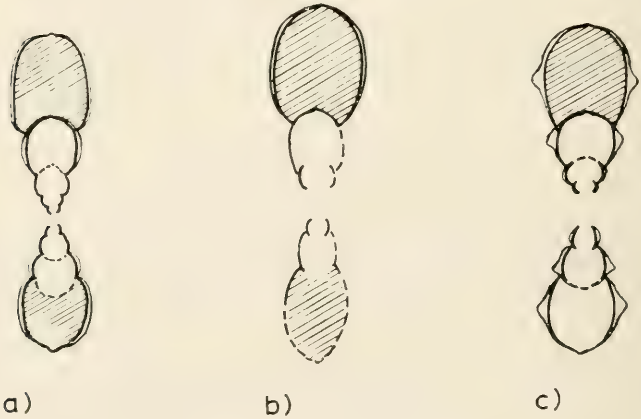
Type species, *P. gerzensis* Trauth, 1930, emend. Westermann, 1954 (p. 125) [the lectotype (Trauth. 1930, fig. 14) chosen by S. D. Moore and Sylvester-Bradley, 1957 is atypical].

Praestriaptychus (subgen. nov. ?) **antiquus** Westermann, sp. nov.
Pl. 62, fig. 7; Pl. 73, fig. 12

A pair of similarly sized valves apparently belonging to a single diaptychus were found in the umbilicus of a specimen of *Erycitoides* (*Kialagvikes*) cf. *E. kialagvikensis* (White) from Shell locality A 85 in the Middle *E. howelli* Zone, late Early Bajocian. The dimensions of the single valves are aproximately 12×16-17 mm. and thus obviously not referable to the small *E. (Kialagvikes)* which is the only abundant associate in this bed. Yet a single poor whorl fragment, measuring 20-25 mm. in height, of an *Erycitoides s.s.* sp. indet., comes from the same assemblage. Based on recent reconstructions of the original orientation of aptychi in the body chambers (Westermann, 1954, p. 126, and Schindewolf, 1958, p. 23) the corresponding whorl section can be estimated to be approximately



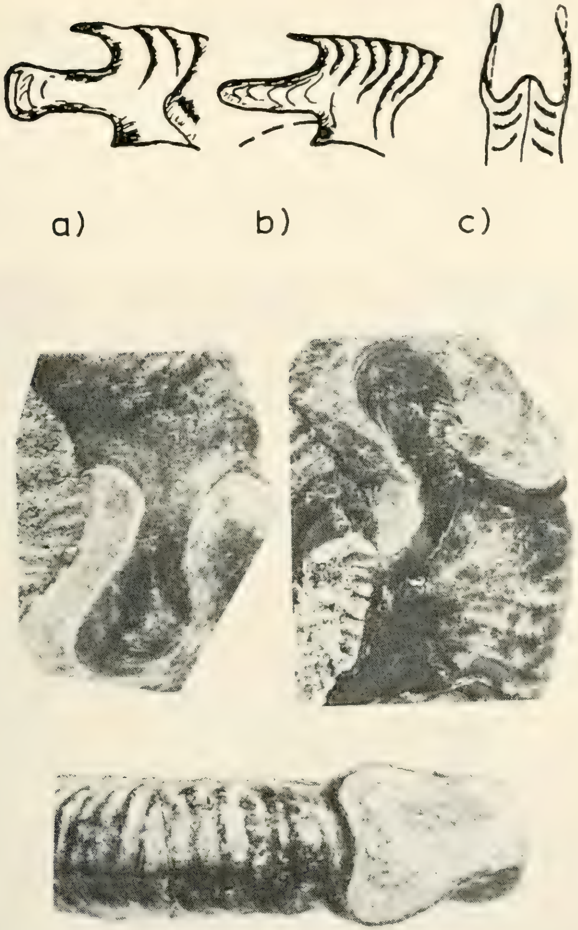
Text-fig. 18. *Podagrosiceras athleticum* Maubeuge and Lambert; holotype, newly prepared, ventral view of body chamber (?); X 2. "Aalenien", territory of Neuqúen, Argentina.



Text-figs. 19a-c. Cross-sections of *Erycitoides* (*Kialagvikes*) spp., from Wide Bay. a) *E. (K.) kialagvikensis* (White), complete specimen, loc. F 59 in basal Upper *E. howelli* Zone (Pl. 63, fig. 1), X 0.9 b) *E.* (*K.*) *Levis, sp. nov.,* almost complete specimen but partly post-mortem compressed, probably from loc. A9 in Middle *E. howelli* Zone (Pl. 64, fig. 9), X 1.8 c) *E.* (*K.*) *spinatus, sp. nov.,* holotype, well-preserved specimen with beginning of body chamber, loc. A8 in basal Upper *E. howelli* Zone (Pl. 64, fig. 1); X 1.8.

25 mm. wide and more than 20 mm. high, depending on the involution of the whorls.

The valves closely match in shape *Praestriaptychus gerzensis* Trauth as figured from body chambers of *Normannites* spp. from the Middle Bajocian of NW. Germany (topotypes, Westermann.



Text-figs. 20a-d. Complete apertures, with lateral lappets, of *Erycitoides (Kialagvikes)* spp. from the *E. howelli* Zone of Wide Bay. a) *E. (K.)* cf. *spinatus, sp. nov.*, loc. 48 A_1-86 (21245) (Pl. 64, fig. 5); X 1.1. b-d) *E. (K.) kialagvikensis* (White), lateral and external views, loc. A8 (Pl. 62, fig. 5); X 1.1 d) Ditto, single specimen, loc. L1067 (U.W., 16666); X 2.

1954, p. 126, pl. 33, figs. 1-7). They differ in the absence of "ornament."

Description.—The general outline of the valves is probably moderately elongated and subrectangular. The inner margin is straight and curves gently into the lateral margin. The apical angle is 95-100°. The outer margin is unknown. The valve is gently and almost evenly convex. A narrow deep harmonic furrow is present on the internal mold of the left valve.

The thin calcareous test is largely preserved on the right valve; outside and inside are totally smooth. The visible fine concentric structure is owing to internal growth structures of the translucent test. A thin chitinous underlayer is indicated by black remnants. No punctation is visible.

Comparison.—P. antiquus differs from all described species of this 'genus' in total absence of corrugation or striation. In shape and probably also in shell structure this species resembles *P. gerzensis* Trauth, 1930, emend. Westermann, 1954, *P. anglicus* Trauth, 1930, from the Callovian (prob. conspecific), and *P. fraasi* Trauth, 1930, from the Upper Jurassic. It is significant that the "ornament" varies considerably in all species. Thus *P. fraasi* may be superficially smooth though concentric folds are still present on the inner surface.

Remarks.—This is not only the first reported aptychus from the Middle Jurassic of America but also the first one referable to Hammatoceratidae. This family is classified among the Hildocerataceae which usually possess a *Cornaptychus* or *Laevicornaptychus*. *Praestriaptychus* has been described from the Middle Bajocian to early Cretaceous *Normannites, Itinsaites, Parkinsonia, Kepplerites, Kosmoceras* and perisphintids (Westermann, 1954, Trauth, 1927, 1930, 1931, 1937). They all are considered as descendents of Hammatoceratinae which subfamily includes forms intermediate between the keeled harpoceratids *s.l.* and the stephanoceratids *s.l.* and possibly perisphinctids *s.l.,* without keel (Arkell, 1957, Westermann, 1956). This is especially true for certain species of *Erycites,* a close relative of *Erycitoides,* which rather by definition are referred to this and not to stephanoceratid genera. Smooth aptychi were said to be typical for the boreal realm, where they occur sparsely and ribbed or thick-shelled aptychi are absent (Gasiorowski, 1962, p. 91).

The discovery of the stephanoceratacean and perisphinctacean *Praestriaptychus* in *Erycitoides* gives further support to the hypothesis that Hammatoceratinae of the *Erycitoides—Erycites* group are at or near the root of the named important Middle and Upper Jurassic (and basal Cretaceous) superfamilies.

Repository.—U.W. 16618.

Subgenus **ERYCITOIDES (KIALAGVIKES)** Westermann, subgen. nov.

Type species, *Am.* (*Lillia*) *kialagvikensis* White, 1889.

Diagnosis.—Dwarf *Erycitoides* with lateral lappets, body chamber costae usually rursiradiate.

Age and occurrence.—Late Early Bajocian (late Aalenian), throughout *E. howelli* Zone of Kialagvik and Tuxedni formations, Alaska Peninsula and Cook Inlet (southern Alaska).

Description and comparison.—The subgenus includes rather coarsely spinose forms as well as finely costate forms with obsolescent primaries or fasciculate costation and all intermediaries, yet all are highly evolute and compressed and grow only to a diameter of 25-60 mm. The phragmocone may resemble immature *Erycitoides s.s.* so that identification of *E. (Kialagvikes)* then depends on the presence of flexuous costae, which however, do not normally develop clearly before the last one-fourth to one-half whorl of the adult phragmocone. The body chamber is almost always clearly distinguished by the falcoid or rursiradiate costae and growth lines, indicating the gradual development of lateral lappets.

This subgenus closely resembles and appears closely related to *Podagrosiceras* Maubeuge & Lambert, 1955, which was described with a single species *P. athleticum* and based on a single incomplete specimen from the uppermost Toarcian or (early ?) Lower Bajocian of Neuquén territory, Argentina. The writer recently reinvestigated the holotype. Additional preparation showed that the external ("ventral") features, originally known only from the fragment of the body chamber, are developed in the same way on the penultimate whorl and are not owing to senility; *i.e.,* a keel is totally missing and the costae alternate regularly. The septal suture is as in typical Hammatoceratinae with "retracted" umbilical elements. The aperture is unknown. Because of the "ventral" features *Podagrosiceras* is regarded to be generically distinguishable from *Erycitoides* which has always a keel. (Westermann, 1964a).

In general appearance this subgenus also resembles the sonniniid *Pelecodites* (including *Maceratites* and *Nannoceras* Buck.) from the *S. sowerbyi* Zone from which it is distinguished by the "retracted" umbilical lobes, the generally stronger and more clearly furcating costae with more pronounced distal terminations, and the much weaker keel. The costation may be more like *Poecilomorphus,* another sonniniid, which is however, much stouter and possesses a bisulcate venter. There is also a strong resemblance mainly in the body chamber with certain Graphoceratidae such as *Darellella* and *Pseudographoceras,* which also have lappets; but they do not carry straight bifurcate costation often present in *E.* (*Kialagvikes*) or lateral spines on the phragmocone. Finally the trend towards fasciculate costation is reminiscent of Phymatoceratinae though here never as fully developed. All compared forms differ significantly in the nonretracted umbilical lobe.

There remains then no doubt that the only near relative of this subgenus is *Erycitoides s.s.* The two genera which are almost always found associated, give the firm impression of representing sexual dimorphs, "macroconchs" and "microconchs" respectively, as they are known from most Middle and Upper Jurassic ammonite families. The list of such families now also include the Hammatoceratidae.

Erycitoides (Kialagvikes) kialagvikensis (White), 1889

Pl. 62, figs. 1-6; Pl. 63, figs. 1-7; Text-figs. 19-21

1889. *Ammonites* (*Lillia*) *Kialagvikensis* White (Alaska Peninsula), U.S. Geol. Sur., Bull. 51, p. 69 (499), pl. 13, fig. 7.

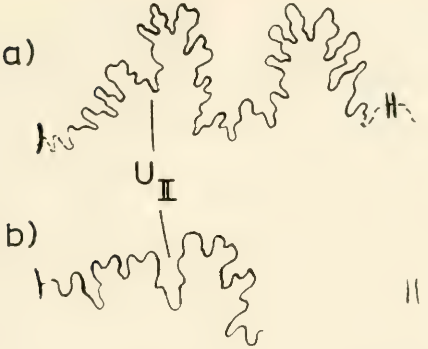
1900. ? *Hammatoceras kialagvikensis* (White), Pompeckj (Alaska), Russ. K. mineral Ges. Verh., ser. 2, vol. 28, p. 275.

1945. *Hammatoceras* ? *kialagvikensis* (White), Kellum, Davies, Swinney (Wide Bay), U.S. Geol. Sur., Prim. report, p. 6, fig. 4C, D.

1959. *Erycites kialagvikensis* (White), Imlay (correl. chart), Geol. Soc. Amer., Bull., vol. 63, pp. 978, 980.

Holotype.—Pl. 19, figs. 1a. b (plastotype); *"A. (Lillia) Kialagvikensis"* White, 1889, pl. 13, fig. 7. Internal mold of mature specimen, ultimate one-half whorl of phragmocone preserved but almost completely compressed, body chamber complete but right side deformed. Repository: U.S.N.M., 132030.

Locus typicus.—Wide Bay [formerly Kialagvik or Wrangel



Text-figs. 21a, b. Septal sutures of *Erycitoides* (*Kialagvikes*) spp., from Wide Bay. a) *E. (K.) kialagvikensis* (White), near end of large phragmocone at 28 mm. diameter, loc. L543 in the Upper *E. howelli* Zone (Pl. 63, fig. 2); X 4. b) *E. (K.) levis, sp. nov.*, 1/4 whorl before end of phragmocone at 16 mm. diameter, incomplete, reversed. Umbilical lobes only slightly "retracted", later sutures become finally "non-retracted", loc. A9 in the Middle *E. howelli* Zone (Pl. 64, fig. 9); X 8.

Bay], probably sea cliff between mouths of Pass Creek and Short Creek, Alaska Peninsula, U.S.G.S. Mesozoic loc. 20086.

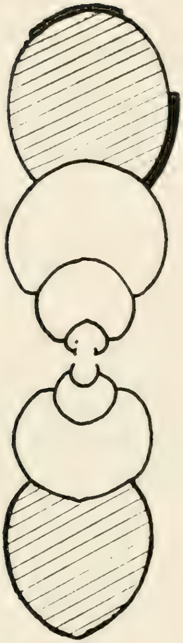
Stratum typicum.—Probably *E. howelli* zonule, Lower *E. howelli* Zone, Kialagvik formation.

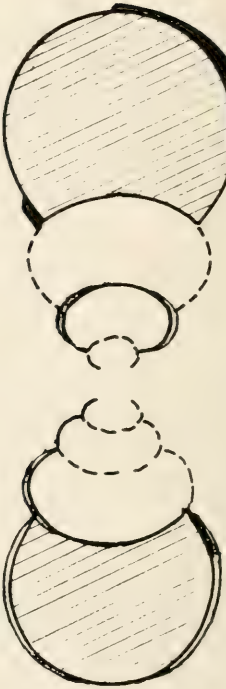
Diagnosis.—A relatively large species of *E.* (*Kialagvikes*); lateral spines or nodes, if present, restricted to nucleus, costae mostly straight except for body chamber.

Age.—Late Early Bajocian (late Aalenian), *E. howelli* Zone.

Material.—? Two body chamber fragments from A 449, fragments from A 443, A 447, one from each 19766 (E 35/36), 19767 (F 37) (*i.e.* rare in the Lower *E. howelli* Zone); 4 fragments from A 7, 5 fragments from A 9, 2+ from A 454, 8+fragments from A 8, fragment from A 5, 1+fragment from A 10, 1+fragment from A 11, 11+from L 543; (*i.e.* abundant in the Middle and Upper *E. howelli* Zone).

Remarks.—The holotype is so poorly preserved and the description so incomplete (defined to the body chamber) that the species name might have to be declared a '*nomen dubium*' if abundant forms undoubtedly conspecific had not been found subse-





Text-fig. 22. Composite cross-section of *Erycites fallifax* Arkell [*E. fallax* auct.], topotype from Cape St. Vigilio, Lago de Garda. From complete body chamber and last phragmocone whorl of Vacek's specimen figured on Pl. 58, fig. 2, and from 2 unfigured nuclei of Vacek's collections. Thick test of apertural constriction partly preserved; X 1.

Text—fig. 23. Cross-section of *Erycites imlayi, sp. nov.,* holotype. Complete specimen with test remains at apertural constriction, loc. 48 A_1-95 (21246) in the *E. howelli* zonule of Wide Bay (Pl. 65, fig. 1); X 1. See page 400.

quently in the same faunal association at or near the type locality. *E. (K.) kialagvikensis* accompanies the much larger *Erycitoides howelli* and *Pseudolioceras mclintocki whiteavesi* in most fossil horizons throughout the *E. howelli* Zone.

Despite the poor preservation of the only two specimens available at that time, White was convinced that this species closely resembled *Erycitoides howelli* "in general form and aspect." White ascribed the only differences to the costation which was said to be flexuous, with fewer secondaries (or intercalatories) and with the greatest strength near their termination, as opposed to *E. howelli*. Yet the specimens were considered to be immature and the aperture described as unknown, though a part of the peristome which clearly indicated lappets, is preserved on the holotype. On the other hand the supposed diagnostic characters, such as few secondaries and the position of their greatest strength, are only apparent or nontypical. Subsequently received knowledge of the phragmocone, aperture, and septal suture suggests that this species is the corresponding "microconch" to *Erycitoides howelli*.

E. (K.) kialagvikensis is so far only known from Wide Bay (formerly Kialagvik Bay) and the Iniskin Peninsula, both in southern Alaska. This does not, however, exclude the possibility of their occurrence in northern Alaska and northeastern Yukon from where *E. howelli* is reported, because the phragmocones of the former may be mistaken for nuclei of the latter species, and so far finds of *Erycitoides* in these areas have been scarce and poorly preserved. The same holds true, of course, for other species of *Erycitoides s.s.* and *E. (Kialagvikes)*.

Description.—The juvenile whorl section is depressed suboval, becomes subcircular in the early ephibic stage at 10-15 mm. diameter, and is more or less strongly compressed suboval and often subrectangular in the adult shell. The whorl sides of the late phragmocone and of the body chamber may be more or less flattened and usually converge slightly. A poorly defined umbilical wall may develop on the body chamber but is absent on the phragmocone. The fine blunt solid keel and the accompanying smooth zone are present throughout the ephibic stage and mostly up to the aperture. The umbilicus of the mature whorls is extremely wide, 40 to almost 50% of the diameter, and shallow.

The ornament develops at approximately 3.5 mm. diameter; about 12-14 blunt lateral nodes are mostly present on the first ephibic whorl ending at 7-8 mm. diameter. On the next whorl these may strengthen to spines or remain blunt and extend towards the umbilical seam into primaries or become more like bullae, at a frequency of 8-11 per halfwhorl. Some specimens, however, appear to be smooth at least on the inner side of the whorls up to this stage. At a diameter of approximately 10 mm. the lateral spines, nodes, or bullae are generally reduced and 9-12 blunt primaries are present on the halfwhorl ending at about 15 mm. diameter. The primaries become subsequently more densely spaced at frequencies of 12-15 per halfwhorl on the last whorl of the phragmocone. Some lateral tubercles may be present irregularly on every other or third primary or so. At about 10 mm. diameter secondaries mostly develop by irregular bifurcation, mostly markedly fasciculate, and as intercalatories, often arising on the inner flank. The costation at this stage is strongly reminiscent of subfasciculate variants of *E. howelli*. Usually rectiradiate and projected it becomes more or less strongly flexuous only at the end of the phragmocone at 20-25 mm. diameter. There are 14-17 primaries and 28-32 secondaries per halfwhorl on the body chamber; they become increasingly flexuous up to the aperture with typically rursiradiate and projected secondaries indicating the gradual development of lateral lappets. By reduction of the primaries mainly on the inner parts of the flanks proceeding from the umbilical shoulders and by extended secondaries the differentiation of costae in primaries and secondaries becomes often obscure. There is still much variation in strength and curvature of the costae. On the first halfwhorl of the body chamber the rursiradiate secondaries project only moderately and reach the keel zone approximately perpendicularly; before the aperture, however, their curvature more than outweighs the increased rursiradiate deflection resulting in a marked projection. The secondaries do not decrease in strength up to their sudden termination at the medial smooth zone which is generally rather broad on the internal mold, yet mostly narrow on the test.

The body chamber varies little about a length of three-fourths whorls. The final diameter lies usually between 40 and 55 mm., rarely as little as 30-35 mm. and as large as 60 mm. At the aperture the last costae are laterally strongly projected and on the internal mold markedly flattened. This feature and a minor constriction on the flanks adjoining the peristome on the internal mold is probably owing to an internal thickening of the test. The peristome has straight and long (ca. 10 mm.) yet narrow and simple lateral lappets with parallel borders. There is also a broad, much shorter "ventral" lappet. Except for the lateral lappets the peristome is rather reminiscent of *Erycitoides s.s.*

The septum and suture resemble those developed in young

Erycitoides s.s. The little frilled suture displays a deep external lobe E, a large and broad ("1st") lateral lobe L and a greatly reduced oblique second umbilical ("lateral") lobe U_2. The L/U_2 saddle is slightly higher than the E/L saddle and forms a complex with the U_2/U_3 (third lateral) saddle. The third umbilical lobe U_3 is strongly retracted.

Holotype.—It is larger than average and the preserved ultimate halfwhorl phragmocone commences at 28 mm., the usual mature diameter. The phragmocone is strongly deformed by lateral compression, yet rather densely spaced moderately strong and slightly flexuous primaries can be distinguished. The three-fourths whorl body chamber is of compressed suboval section and bears 14-15 rather weak primaries and approximately 30 secondaries per halfwhorl. The costation is flexuous, markedly fasciculate and reduced on the umbilical slope obscuring the identity of the primaries. The fine blunt keel and the smooth adjoining band continue up to the aperture which is indicated by fragments of the peristome.

Measurements.—

	D mm.	H%	W%	U%	P	S
holotype (aperture)	55	32	25	42	14-15	ca.30
(phragm.)	37					
1. hypotype (aperture)	46	33	27	45	15-16	31
(phragm.)	30	35	28	41	14	ca.28
"	21	36	32	38	12	—
"	11	50	ca.53	37	7- 8	—
2. hypotype (aperture)	ca.43	ca.30	—	ca.45	13	29
(phragm.)	39	31	28	39	11	—
	20	—	—	—	12-13	—
	15	—	—	—	9	—
	10	—	—	—	9	—

Erycitoides (Kialagvikes) spinatus Westermann, sp. nov.
Pl. 64, figs. 1-6; Text-figs. 19c, 20a

Holotype.—Pl. 64, figs. 1a, b; almost complete internal mold with test remains on nucleus. Repository: U.W., 16624.

Locus typicus.—Shell locality A 8, Moose Creek-Mt.-Kathleen section, Wide Bay, Alaska Peninsula.

Stratum typicum.—Near base of Upper *E. howelli* Zone, Kialagvik formation.

Age.—Late Early Bajocian (late Aalenian), Middle and Upper *E. howelli* Zone.

Diagnosis.—A strongly spinose though generally finely costate species of *E. (Kialagvikes).*

Material.—The holotype + 1 almost complete internal mold with test in umbilicus, from A8; two incomplete internal molds+1 body chamber fragment from F 12 (=48A_1-86, 19747, 21245); one small incomplete and compressed internal mold from 48A_1-109 (21254).

Description.—The juvenile whorls, up to about 10 mm. diameter, resemble the finely spinose variants of *E. (K.) kialagvikensis.* In *E. spinatus,* however, this ornament is retained up to the body chamber and strongly elevated primaries or bullae, often with tubercles are present up to the aperture. On the nucleus the costae are only of moderate strength, the primaries rather widely spaced and the secondaries, born by tri-furcation and intercalation, are usually densely spaced. On the larger specimens the costation becomes much stronger at 20-25 mm. diameter and mainly the secondaries become wider spaced.

The body chamber becomes increasingly compressed and the costae rursiradiate in differing degrees. The aperture has simple large lateral lappets as in *E. kialagvikensis.*

The septal suture is identical to that of *E. kialagvikensis.*

Remarks.—The holotype and the single specimen from U.S.G.S. locality F 12 (Pl. 64, fig. 5) are doubtless identical. Both specimens appear to be mature at a final diameter of about 30 mm., the whorls are strongly compressed and somewhat fastigate on the holotype, and the secondaries remain fine and densely spaced up to the end of the halfwhorl preserved body chamber. The other four specimens differ in the coarser secondaries and in the less defined, more elongated or thicker spines. They are possibly not conspecific and perhaps are extreme variants of *E. kialagvikensis.*

Comparison.—*E. spinatus* is distinguished from *E. kialagvikensis* in the retention of the lateral spines. *Erycitoides (s.s.?) paucispinosus* is more depressed and has probably a simple aperture; this species may be the corresponding 'macroconch' dimorph.

Measurements.—

	D mm.	H%	W%	U%	P	S
Holotype (body chamber)	28	30	25	43	8	32
(phragm.)	20	32.5	30	41	7	ca.22
	10	35	40	37	9	—
(A 8) (body chamber)	41	ca.32	ca.26	48	13	29
(phragm.)	31	33	30	45	11	ca.25
	25	36	ca.34	41	11	—
	15	—	—	—	9	—
	10	—	—	—	10-11	—
	7	—	—	—	10	—

Erycitoides (Kialagvikes) levis Westermann, sp. nov.
Pl. 64, figs. 7-12; Text-figs. 19b, 20b, c.

Holotype.—Pl. 64, figs. 7a-e; almost complete internal mold. Repository: U.W., 16626.

Locus typicus.—Shell locality A 456, lower Short Creek Valley, Wide Bay, Alaska Peninsula.

Stratum typicum.—About base of upper third of the Upper *E. howelli* Zone, Kialagvik formation.

Age.—Late Early Bajocian (late Aalenian), (Middle and Upper) *E. howelli* Zone.

Material.—One from A 9, two from A 454, four (+2?) from A 85 (Middle *E. howelli* Zone); ? two (+1) from A 456, ? one from L 543 (near top of Upper *E.* howelli Zone), Wide Bay; one from B 128 Puale Bay.

Description.—The adult size of this species is only 25-35 mm. and accordingly, the phragmocone does not exceed 25 mm. The evolute whorls become compressed-ovate generally at or before a diameter of 10 mm. The adult whorl section is, therefore, mostly strongly compressed, the sides somewhat flattened and the externside acutely rounded. The keel of the preserved internal mold is weak, sometimes obscure, and may resemble a slightly acute "venter."

The early ephibic stage (approximately 4-10 mm.) is laterally smooth or may bear an irregular broad undulation, obscure blunt primaries or even blunt nodelike elevations. Subsequently weak more or less flexuous costae develop. There are about twice as many secondaries as primaries which arise irregularly by fasciculation. The weak secondaries are more or less strongly projected and die out somewhat gradually, leaving a broad smooth medial zone. As usual the costae decrease laterally in height in approaching the aperture. The primaries may fade, commencing from the umbilicus, and the inner third of the flank may thus become smooth on the last halfwhorl of the body chamber.

Remarks.—The aperture and its peristome apparently resemble *E. kialagvikensis,* so do the septum and suture, though the "sutural lobe" U_3 may be comparitively little retracted on small specimens.

This species is somewhat reminiscent of certain dwarf Graphoceratinae and Phymatoceratinae rather than the younger Hammatoceratinae. Yet, it is doubtless a near relative of *E.* (*Kialagvikes*) *kialagvikensis,* which it resembles in the outer whorls and the suture.

Genus **ERYCITES** Gemmellaro, 1886

Type species, *E. fallifax* Arkel, 1957 [*Am. fallax* Benecke, 1865, *non* Guerange, 1865]. See Text-fig. 22, page 394.

Erycites imlayi Westermann, sp. nov.
Pl. 65, figs. 1, 2; Pl. 75, figs. 2a-c; Text-figs. 23, 24

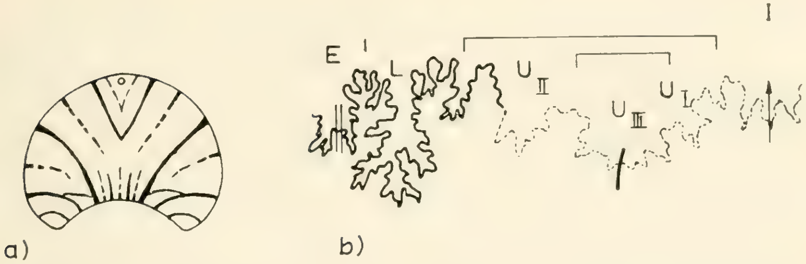
Holotype.—Pl. 65, figs. 1a-e; phragmocone with test, slightly compressed, left umbilicus not preserved, complete body chamber as internal mold with test remains (Coll. Imlay and Miller, 1948). Repository: U.S.N.M. 132 039.

Locus typicus.—U.S.G.S. Mesozoic locality $48A_1$-95 (21246), sea cliff southwest of mouth of Pass Creek, Wide Bay, Alaska Peninsula.

Stratum typicum.—*E. howelli* zonule near base of *E. howelli* Zone, Kialagvik formation.

Age.—Late Early Bajocian (late Aalenian), Lower *E. howelli* Zone, *E. howelli* zonule.

Derivatio nominis.—In honour of R. W. Imlay, U.S. Geological Survey (see Preface).



Text-fig. 24a, b. *Erycites imlayi, sp. nov.*, loc. 48 A_1-95 (21246) in the *E. howelli* zonule of Wide Bay. a) Septum at 50 mm. diameter, saddle axes indicated by solid lines, lobe axes by dashed lines; 1st saddle axes, corresponding to the 1st lateral saddles (E/L), fuse centrally; X 1. b) Complete septal suture at 35 mm. diameter, composed from holotype (solid line, reversed) and paratype (pointed line); X 1.5.

Material.—The holotype and a second, almost complete specimen with both umbilici preserved, phragmocone with test, half-whorl of body chamber as internal mold. From 48A_1-95 (21246), basal *E. howelli* Zone, *E. howelli* zonule, Wide Bay, Alaska Peninsula. (See also Appendix).

Diagnosis.—A medium-sized species of *Erycites* with moderately evolute and depressed-oval (ellipsoidal) whorls of the phragmocone. Costation moderately coarse, no tubercles; keel minute and only superficial, partly obsolescent.

Description.—The neanic whorls are evolute, apparently subcircular and smooth. The last two whorls of the phragmocone, commencing at approximately 15 mm. diameter, are moderately and slightly increasingly evolute (U=28-37%) and of rather broad-oval section (W/H=1.4-1.7) with narrowly rounded to almost evenly rounded whorl sides. The umbilical slope is markedly to strongly convex and meets the umbilical seam at about 40-70° to the symmetry plane of the conch. The largest width of the whorls lies at or only slightly below the middle of the sides. The two specimens differ markedly in whorl section and umbilical width but are here considered variants of a single species. The phragmocones terminate at 52 and 53 mm. respectively. (See also Appendix).

The body chamber egresses, its section becomes finally almost subcircular with slightly flattened and somewhat converging sides and high-rounded externside. The three-fourths whorl body chamber of the holotype bears a simple aperture with greatly thickened (3 mm.) test, marked on the internal mold as a strongly oblique, broad constriction, and a slightly trumpet-shaped peristome. The final diameter is between 90 and 95 mm.

The costation of the phragmocone, commencing at approximately 10 mm. diameter, consists of 11-13 markedly prorsiradiate straight primaries which reach gradually moderate strength on the middle of the sides, *i.e.*, over the largest whorl width or slightly above. They bifurcate and, rarely, tri-furcate into straight recti- or somewhat prorsiradiate blunt secondaries which only rarely arise by intercalation. There are between 30 and 38 secondaries per halfwhorl. They are medially interrupted causing a rather broad smooth band, 1½-2 plicae distances in width. On the test, but not on the internal mold, of the ephibic stage (preserved above 30 mm. diameter only) a minute ribbon-like keel or an extremely blunt medial elevation is present for short intervals only. Elsewhere the externside is smoothly rounded superficially as is usual on the internal mold.

On the body chamber the costation becomes blunter though clearly discernible up to the aperture in similar frequencies of primaries and secondaries as on the late phragmocone. The widely spaced secondaries become stronger prorsiradiate and somewhat projected; they end gradually and alternately along the median line but may finally be continuous near the end of the body chamber, though largely reduced in elevation. The internal mold suggests that a keel was absent also on the test.

The septum (Text-fig. 24a) belongs to the planulate maintype (Westermann, 1956, 1958) and possibly to the 'normal orthochrone' division as is suggested by the seemingly nonretracted neanic suture visible on the umbilicus of the large specimen, though the "sutural lobe" is strongly retracted at least commencing from 10 mm. diameter (Text-fig. 24b). This is strongly reminiscent of *Erycitoides.* The outer (lateral) saddle axis, corresponding to the L/U_2 (second lateral) and the dominant I/U_1 (internal lateral) saddles, is the major structure. A small inner (central) semi-axis builds a chevron beside the small (outer) rudimentary central lobe axis, corresponding to the small E/L (first lateral) saddle and external lobe E. The shallow inner part of the central lobe axis is subdivided by a pair of minute subparallel axes corresponding to the trifid shallow internal lobe I (Text-figs. 24a, b).

The septal suture is characterised by the short external lobe E, hardly half the size of the large lateral lobe L. The E/L saddle is small and oblique though its adapertural 'boundary' is not much below that of the large L/U saddle. The second umbilical lobe U_2 ("second lateral") is small and oblique, U_3 strongly 'retracted'. The internal suture, hitherto unknown from *Erycites,* is characterised by a greatly dominating (second ?) 'internal lateral" saddle (? U_1/U_3) and a strongly reduced inclined "1st (?) internal lateral" lobe (U_1?) (which at its outer flank appears to separate a small inclined 1st lateral saddle). The supposed first lateral lobe is analogous to a large 'accessory lobe' (incision, indentation), but probably equivalent to the 'hanging' lobe usually called U_1 in Stephanoceratids (Westermann, 1956, 1958). The internal lobe I is as short as *E.* The internal part of U_3 is also strongly 'retracted'.

Septum and suture agree in every significant detail with those studied by the author on topotypes of *Erycites fallifax,* kindly loaned by the Geologische Bundesanstalt, Wien, and with external sutures figured from other species of the restricted genus by Prinz (1904), Meneghini (1915), Merla (1934), and others.

Comparison.—This species is more evolute (at least the nucleus), has more depressed whorls (Text-fig. 22) and is coarser costate than *E. fallifax* Arkell [=*E. fallax* Benecke, 1865, *non* Gueranger, 1865; see figures of topotypes in Vacek, 1886, pl. 15], *E. sphaeroconicus* Buckman, possibly only a globose variant of the former, and *E. amelus* (Gregorio). *E. imlayi* is more involute and depressed than *E. gonionotus* (Benecke), *E. crassiventris, E. rotundiformis. E. brevispina, E. elaphus,* Merla spp., *E. schafarziki* [*E. intermedius* and *E. retrorsicostatus,* Prinz spp., are incompletely known and possibly conspecific with the latter]. *"E." baconicus* and *"E." eximius* Prinz spp., belong to the *Hammatoceras-Eudmetoceras* group.

Remarks.—A restudy of a number of *E. fallifax* from the type locality, all from Vacek's collection, including his originals, kindly received on loan from the Geologische Bundesanstalt Wien, shows that the keel is always minute and often only superficially present. The internal mold may only display a smooth median band or its central part may be slightly raised into a blunt hardly separated "keel" and this may change repeatedly throughout at least the two ultimate whorls of the phragmocone. Thus there is a continuous gradation in this respect from *Erycites* to *Abbasites*. *Abbasites* is, however, distinguished in the whorls section which is more compressed with a narrowly rounded or sharp lateral *(not* umbilical) edge.

The holotype somewhat resembles *Abbasites* in the whorl shape while the other specimen has evenly rounded sides. However it possessed a minute keel and the same planulate septal and sutural pattern as latter specimen.

Measurements.—

		D mm.	W%	H%	U%	P	S	W/H
Pl. 64, fig. 1	(aperture)	93	33	29	39	14	ca.36	1.15
	(phragm.)	54	52	37	37	13	ca.38	1.4
		39	60	38	31	13	38	1.6
		29	70	41	30	12	—	1.7
Pl. 64, fig. 2	(body ch.)	67	38	35	37	11½	30	1.1
	(phragm.)	52	44	36	34	13	—	1.2
		37	52	37	31	13	35	1.4
		29	55	40	28	13	ca.30	1.4

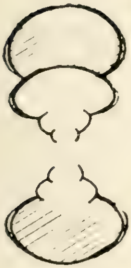
Genus **ABBASITES** Buckman, 1921

Type species, *Abbasites abbas* Buckman, 1921 [=? *A. cestiferus* (Brasil) 1895]

Abbasites is here distinguished generically from *Erycites* on the grounds of its significantly different septum (and suture) which is of the planulate type in *Erycites* but typically of the bullate type in *Abbasites*. In the inner suture this is mainly evident in the single dominant saddle in the former and the subequal pair of saddles in the latter. The external suture is distinguished in E which is very short in *Erycites* but long in *Abbasites*. These are differences not or not sufficiently observed before.

Abbasites platystomus Westermann, sp. nov.
Pl. 66, fig. 1, 2, Text-figs. 26a, b.

Holotype.—Pl. 66, figs. 1a-c; a well-preserved, uncompressed



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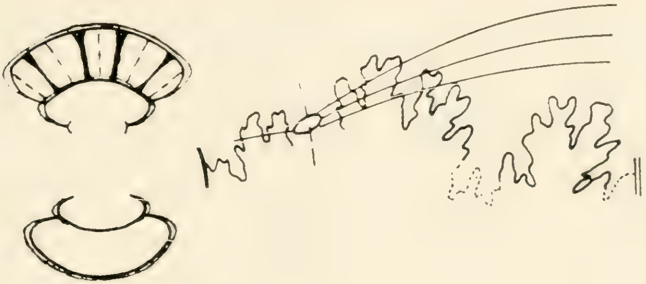


26a) 26b)

Text-fig. 25. Cross-section of *Abbasites abbas* Buckman, plastotype, complete; X 0.7.

Text—fig. 26. *Abbasites platystomus, sp. nov.,* holotype, loc. A444 in the *E. howelli* zonule of Wide Bay (Pl. 66, fig. 1). a) Cross-section with septum, saddle axes indicatel by solid lines, lobe axes by dashed lines; X 0.7 b) Septal suture at 38 mm. diameter, slightly simplified, costation indicated. X 2.

internal mold, nucleus and body chamber missing. Repository: U.W., 16632.

Locus typicus.—Shell locality A 444, at sea cliff approximately 0.5 km. southwest of mouth of Pass Creek, Wide Bay, Alaska Peninsula.

Stratum typicum.—Lower Kialagvik formation, *E. howelli* zonule at base of *E. howelli* Zone.

Age.—Late Early Bajocian (late Aalenian), *E. howelli* Zone.

Material.—Besides the holotype, a poorly preserved nucleus, compressed except for ultimate 1/4 whorl, from U.S.G.S. Mesozoic locality F 21 (19755) at Short Creek, Upper *E. howelli* Zone.

Diagnosis.—A cadicone species of *Abbasites* with greatly depressed, evolute whorls.

Description.—The whorl section of the phragmocone is more than twice as broad than high. The sharp lateral edge comprises a right angle and is situated at half whorl height. The broad externside is gently and evenly rounded, the inner sides grade into the vertical umbilical wall. The deep umbilicus measures in width more than 40% of the diameter.

The ornament consists of 12-15 rectiradiate primaries per half-whorl which arise progressively distantly from the umbilical seam, strengthen rapidly and carry tubercles, later bullae-like extended, on the lateral edge. The densely spaced secondaries arise by bifurcation and, more rarely, tri-furcation. They become progressively prorsiradiate beyond a diameter of about 10 mm., and irregularly alternate, comprising an increasingly distinct angle at the narrow smooth median band. Commencing at 20-25 mm. diameter the secondaries become externally increasingly convex and medially more and more almost continuous. At the end of the preserved phragmocone the secondaries are continuous though partly somewhat flattened approximately describing a caternary curve.

The septum is of the bullate structural main type typified by two subequal pairs of saddle-axes (Text-fig. 26a). The suture (Text-fig. 26b) displays the unique features of *E. abbas;* the E/L saddle is unusually small, yet E is nearly as deep as L, U_2 is strong and lies on the umbilical edge, the U_2/U_3 saddle is relatively large and U_3 narrow and not markedly retracted. The internal suture displays two subequal lateral saddles separated by a deep vertical U_1.

Comparison.—The original size of the holotype was at least 60 mm. D and thus much larger than the English species *A. abbas* (Text-fig. 25) and *A. aegrotus,* Buckman spp. which also have no lateral tubercles or bullae. The American species is much more depressed and evolute than the English ones, the types of which are said to come from the upper *L. murchisonae* Zone, *L. bradfordensis* Subzone.

This species is almost homeomorphic to certain species of the circumpacific *Pseudotoites* fauna from the directly overlying beds of the early *S. sowerbyi* Zone. These forms, however, display the "normal" septal suture with large E and adjoining saddle, and continuous secondaries throughout. This resemblance almost certainly reflects a physic relationship.

Remarks.—The occurrence of *Abbasites,* described from the generally condensed Upper *L. murchisonae* and *G. concavum* Zones of southern England (Buckman, 1921, Bomford, 1948) and now identified in the condensed Cape St. Vigilio beds of the southern Alps (late *L. jurense* to early *S. sowerbyi* Zones), near the base and near the top of the *E. howelli* Zone is suggestive for a late Lower Bajocian age of the American sequence. The reference of *'Coeloceras' modestum* Vacek (1886) and *'C.' modestum compressum* Prinz (1904) to *Abbasites* by Geczy (1961) cannot be confirmed, though this relationship seems as probable as with *Docidoceras,* suggested by Arkell (1956); it is in accordance with the *Erycites*-type suture. The species occurs in the Cape St. Vigilio beds and also, mainly in the *T. scissum* zone, of the Bakony Mountains, Hungary. *Abbasites* cf. *A. aegrotus* (Buckman) is identified from unfigured specimens in Vacek's collection from Cape St. Vigilio, kindly loaned by the Geologische Bundesanstalt Wein. *"Erycites cestiferum"* Brasil (1895) is probably identical with *A. abbas;* it was described from the *G. concavum* Zone of Normandy.

Measurements.—

	D mm.	W%	H%	U%	P	S
Holotype						
(phragm.)	ca.44	75	34	44	ca.15	ca.40
"	28	79	33	42	12	—
	ca.20	ca.90	ca.43	—	ca.12	ca.28
E. abbas						
(body ch.)	28	65	36	34	15	ca.35
"	23	74	37	34.5		
E. aegrotus						
(body ch.)	21	83	47.5	26	ca.16	ca.35

Genus **EUDMETOCERAS** Buckman, 1920

Type species, *E. eudmetum* Buckman, 1920.

Taxonomy.—The taxonomy of the Hammatoceratinae is in a poor state mainly with regard to those early Bajocian poorly defined species described or attributed to the "genera" *Eudmetoceras, Parammatoceras, Planammatoceras, Euaptetoceras,* all of Buckman, 1920-25. The author attempts some clarification of their taxonomic status mainly based on a comparative study on the holotypes of the type species which could be studied, together with all of Buckman's rich collection in the Geological Survey of Great

Britain in summer 1962. The same survey had also kindly furnished the principal plastotypes prior to this visit.

Eudmetoceras.—E. eudmetum is a large, evolute, compressed form with flattened sides and a steep, sharply separated umbilical wall typically developed during maturity. The keel is high, hollow-floored and well separated. The costation of the nucleus is characterised by strong and sharp primaries, some of which grow especially high and carry at irregular intervals nodes or spines adjoining to and often "impressed" into the succeeding umbilical wall. On the holotype the primaries of the nucleus are born at the umbilical seam and are almost entirely of similar strength carrying only few weak nodes. The umbilical slope begins at 50 mm. diameter and is always smooth. Topotypes, however, have much more dissimilar early primaries which may be born at some distance from the umbilical seam and rise steeply to uneven spines. The secondaries are strong but blunt, usually almost straight, slightly prorsiradiate and distally somewhat projected. Many of the secondaries are most nearly in a straight line with the primaries and extra strong thus producing the illusion of "long primaries" often stated as typical for *Eudmetoceras*. Long intercalatories and fasciculation of extended secondaries are typical for the early mature stage, before the costae flatten and become finally obscure on the whorl sides. The septal suture is typically hammatoceratid with strongly retracted umbilical elements.

The early whorls significantly resemble early and intermediate stages of *Sonninia*, especially those of *S.* (*Euhoploceras*) of the lower *S. sowerbyi* Zone, with the exception of the suture which is non-retracted in *Sonninia*.

Eudmetoceras eudmetum has only been known from the "*Eudmetoceras* hemera" of the *G. concavum/S. sowerbyi* Zone boundary of Dorset, England. However, a single specimen in the Buckman collection labelled "*Sonninia* (*Parammatoceras*), from the *L. murchisonae* Zone of Sherborne, Dorset," appears to be identical with *Eudmetoceras eudmetum*. *E. eudmetum* may consequently have a range similar to that suggested for *E. amaltheiforme*. The nearest relative from Europe is probably *E. insignoides* (Quenstedt), 1886, redescribed and refigured by Dorn (1935, p. 21, pl. 1, fig. 3; text-fig. 1, fig. 5, 6); it is known only in a single specimen which, according to Quenstedt, originated in the *G. concavum* Zone or *S. sowerbyi* Zone of Scharzingen in the Swabian Alb. Some irregularity of the primaries is present in the adolescent stage according to recent restudy of the holotype by the author. The nearest resemblance, however, is found in the Argentine and Alaskan forms described below. *Eudmetoceras (s.s.)* cf. *E. eudmetum* has now been identified in a single specimen from the *S. sowerbyi* Zone of Wide Bay.

E. (Euaptetoceras) Buckman, 1922.—The type species, *E. euaptetum* Buckman, 1922, is regarded as synonymous with *E. amaltheiforme* Vacek, 1886, from the condensed beds of Cape St. Vigilio in the Alps. The type species of *Parammatoceras* Buckman, 1925, *P. rugatum* Buckman, 1925, is indistinguishable according to the writer's study of the holotypes. Thus *Parammatoceras* becomes a synonym of *Euaptetoceras* and not of *Planammatoceras* as suggested by Arkell (1957, p. L 267). "*P. rugatum*" was said to come from the *L. murchisonae* Zone of Dorset, one or, may be, two zones below the "*Eudmetocera* hemera". This slight age difference was probably responsible for their generic discrimination by both Buckman and Arkell.

E. amaltheiforme reaches as large a size as *E. eudmetum* and is characterized by involute compressed whorls of rectangular-trapezoidal section with a high vertical sharply separated umbilical wall and a high hollow-floored keel. The body chamber egresses appreciably, but the umbilical margin remains sharp. The costation resembles that of *E. eudmetum* with its steeply rising primaries carrying some irregular nodes and spines "impressed" in the subsequent umbilical wall; again, some primaries may be born off the umbilical seam already before the early introduction of the always smooth vertical umbilical wall. The costation becomes reduced and the sides smooth at a somewhat earlier stage than in *E. eudmetum*. The body chamber is missing in the holotype and incompletely preserved in the other specimens. The septal suture is moderately "retracted" much more clearly than in "*P. rugatum*"; this difference is not regarded as systematic since "retraction" is often reduced or obscured on involute forms.

E. amaltheiforme is also known from the *G. concavum* Zone of the Swiss Jura where it is associated with *E. amplectens* (Buckman) (Maubeuge, 1955, p. 33 pl. 6, figs. 3-5).

"Hammatoceras" sieboldi (Oppel), 1882, the holo-plastotype of which, said to have come from the *L. murchisonae* Zone of Aalen, Württemberg, was kindly furnished by W. Barthel from the University of Munich, appears to be a rather typical *Eudmetoceras* (*Euaptetoceras*). The nucleus, up to a diameter of 40-45 mm. is characterized by heavy lateral nodes on the internal mold probably corresponding to nonpreserved spines on the test, which were "impressed" in the subsequent vertical though rounded umbilical wall. At this stage primaries are obsolescent; they develop later, rather strongly concurrently with the fast reduction of the nodes/spines. This phyletic relationship is strongly suggested by Vacek's (1886, pl. 11, figs. 6-7, pl. 12, fig. 1) assemblage from Cape St. Vigilio. The specimen figured on his plate XII, figure 1 is a typical *E. sieboldi* but not the specimens figured on plate XI, figures 6-7 as suggested by Arkell (1957, p. 176). The latter ones, however, closely resemble and are certainly conspecific with *E. amaltheiforme* and especially *"Parammatoceras rugatum"*, a probable synonym. They differ only in the stronger reduced primaries and stronger nodes/spines on the early nucleus up to 20-25 mm. diameter. It was, however, shown above that such deviation also occurs within *Eudmetoceras s.s.* Consequently, *"H." sieboldi* and a number of described related species, not mentioned here, belong to *Eudmetoceras* (*Euaptetoceras*).

Eudmetoceras amplectens (Buckman) resembles *E. amaltheiforme* (Vacek) in whorl shape but differs in the thinner and often longer primaries which may become obsolescent. *E. amplectens* may, therefore, resemble also *"Hammatoceras" klimakomphalum* Vacek, originally described from the Cape St. Vigilio beds, which is now considered to be a *Strigoceras* (subgen. nov.?) on the strength of its "lanceolate" whorl shape and the occurrence of strongly flexed growth lines and spiral striae on Wide Bay specimens from the *S. sowerbyi* Zone (described in part II of this monograph). When preserved without the hollow-floored keel, *E. amplectens* may also resemble *Bradfordia* or *Oppelia*. Other *Eudmetoceras* species are distinguished from *E. amplectens* in the well-defined umbilical margin which is usually well-rounded here; however, test and internal mold differ in this respect because the test may be thickened along the margin.

The variation in costation of *E. amplectens,* particularly with regard to the primaries, was observed within, supposedly, a single sample from Bradford Abbas, Dorset, in the Buckman collection (Geol. Sur. London). The complete gradation from forms without primaries, *i.e.* typical *E. amplectens,* to those with blunt long primaries on the inner whorls, labelled *"Eudmetoceras* aff. *amaltheiforme"* by Buckman, was already recognized by that author and the specimens consequently included in a single genus; certainly a significant fact in the light of the extreme generic "splitting" pursued by him. A co-variation of costation and whorl section can be observed; the primaries strengthen and lengthen towards the umbilicus with the sharpening of the umbilical margin which finally also becomes costate.

Eudmetoceras (Euaptetoceras) amplectens is known from the *G. concavum* Zone and/or *H. discites* Subzone of Dorset, England, and from the *G. concavum* Zone of southeastern France, northwestern and southwestern Germany, and northern Switzerland. The same species is described here from the lower and upper *E. howelli* Zone of Wide Bay.

Planammatoceras Buckman, 1922.—The type species is *P. planiforme* Buckman, 1922, here regarded synonymous with *P. planinsigne* and *P. tenuinsigne,* from the Cape St. Vigilio beds of the southern Alps. *P. planinsigne* probably also occurs in Japan and appears to be confined to the *L. murchisonae* Zone. The type species is characterized by median-sized moderately evolute compressed-oval whorls. Umbilical wall and margin are missing or insignificant and mainly present only on the internal mold. The thin keel is high and hollow-floored. The thin even primaries arise near the umbilical seam and reach only up to one-third to two-fifths of the sides, where they may either continue into one of the generally thinner and much more frequent secondaries, as on the holotype of *"P. planiforme"* or reduce rather suddenly and give rise to a number of equal secondaries, as in the holotype of *P. tenuinsigne.* Weak lateral tubercles or nodes may be present as on the holotype of *P. planinsigne.* There is a lateral reduction of the costae only at the end of the body chamber. The subsequent umbilical seam lies well outside the point of costae division. The aperture is simple.

Other species of *Planammatoceras* appear to be *P. procerin-*

signe (Vacek) and *P. "lorteti"* (Vacek), *non* Dumortier [=*P. vaceki* Roman, 1923, *non* Prinz, 1904, *non* Brasil, 1895], which seem to be more evolute and strongly costate members of the same variate species group (superspecies) including the type species, all from Cape St. Vigilio. The much smaller and on the sides almost smooth *P. tenerum* (Vacek) from the same beds appears to be from just another irradiating trend of this group. It certainly would be an artificial separation of an approximate phyletic unity to assign these species to different genera as was done by Arkell (1956, p. 177). The study of Vacek's specimens, probably all derived from a single lenticular though condensed rock body, strongly suggests this.

Because of a number of described species not mentioned here which seem to occupy an intermediate morphological position between typical *Planammatoceras* and *Eudmetoceras,* the author is awaiting further intensive study of the whole subfamily before taking a definite stand as to whether the former is to be regarded as a separate genus or merely as a subgenus of *Eudmetoceras.*

On first sight the evolute *Eudmetoceras s.s.* and the involute *E. (Euaptetoceras)* may appear to be corresponding groups of dimorphs. However, the similar often large sizes and also the similar apertural shapes of the subgenera make this improbable. Also, both subgenera are not clearly morphologically separated and some species or species groups may possibly include such a variety of forms that it appears at least regionally, as for example perhaps in S. America, impossible or inconvenient to apply this subgeneric division.

Subgenus **EUDMETOCERAS (EUDMETOCERAS)** Buckman, 1920

Eudmetoceras (Eudmetoceras) eudmetum jaworskii Westermann, subsp. nov.

?1878. *Harpoceras* aff. *variable* d'Orb., Gottsche (Espinazito), Palaentographica, Suppl. III, Lief. 2, Abt. 3, p. 12, pl. 1, figs. 9a, b.

1962a. *Hammatoceras lotharingicum* Benecke, Jaworski (Prov. Mendoza), Actas Acad. Nac. Cienc., vol. IX, text-fig. 7, pl. II, figs. 6a, b; pl. IV, fig. 12.

Holotype.—"Hammatoceras lotharingicum Benecke", in Jaworski (*op. cit.*), fig. 7, pl. 11, figs. 6a, b.

Paratype.—Ibid., pl. IV, fig. 12.

Locus typicus.—Cerro Tricolor, locality 18, section 12 of Jaworski (*op. cit.*), Province Mendoza, Argentina.

Stratum typicum.—Horizon 2, "Murchisonae-Concava zone" of Jaworski *(op. cit.)*.

Age.—In the proximity of the *G. concavum—S. sowerbyi* Zones boundary (equivalent), probably *G. concavum* Zone, Bajocian.

Diagnosis.—A highly compressed, strongly costate, and spinose subspecies of *E. eudmetum* of probable moderate size.

Remarks.—The holotype was accompanied by *Eudmetoceras* cf. *E. gerthi* (Jaworski), *"Fontannesia" austroamericana* Jaworski, and *Leptosphinctes (Praeleptosphinctes) jaworskii* Westermann, a fauna rather unsuitable for age correlation. The paratype came from the lower part of Jaworski's horizon 9, section VI, locality 7 at Arroyo Blanco in the same Province, and was associated with *E. gerthi* and *Strigoceras* (*s.s.*) cf. *S. klimakomphalum* (Vacek) [*"Oppelia moerickei"* Jaworski]. From the upper part of the same horizon were described *"Sonninia" fastigata* Tornquist, *"S." zitteli* Gottsche, and *"S." mammilifera* Jaworski, an assemblage of the *S. sowerbyi* or *O. sauzei* Zone. Thus a pre-*S. sowerbyi* or *S. sowerbyi* Zone age is suggested for the *Eudmetoceras* bearing beds.

Eudmetoceras (Eudmetoceras) cf. E. eudmetum jaworskii Westermann, subsp. nov. Pl. 67, figs. 1a, b

Material and age.—A single fragmentary phragmocone internal mold with test remains (U.S.N.M., 132042) from U.S.G.S. locality F 85 (19788), from a bed just above the sea cliff between Anderson and Caribou Creeks, Wide Bay, Alaska Peninsula. This horizon thus correlates with A 22, approximately 2 km. southwest, and belongs in the *Eudmetoceras* zonule of the Upper *E. howelli* Zone.

Description.—The small preserved part of the penultimate whorl, corresponding to a diameter of around 20 mm., shows widely spaced strong lateral spines "impressed" into the umbilical wall of the ultimate whorl, at a frequency of only approximately five per halfworl. The internal mold displays only round heavy tubercles, but the test shows that the high spines were filled with secondary test substance about a millimeter thick. At this stage the whorl section is depressed-oval, possibly somewhat subtriangular, with a well-separated hollow-floored keel. Primaries were probably blunt or obsolescent at this stage.

The fragment of the ultimate whorl corresponds to a diameter of the phragmocone from about 30 to 45 mm. though the external part above approximately 40 mm. is missing. The whorl section is slightly compressed suboval to subtriangular with a thin well separated hollow-floored keel. There are seven or eight straight slightly prorsiradiate primaries, corresponding to a frequency of eight or nine per halfwhorl and extending up to the middle of the sides. The primaries are strongest on the first quarterwhorl where they grow laterally into strong bullae on the internal mold which apparently correspond to spines. At an estimated total diameter of 40 mm. the primaries weaken abruptly and tend to extend onto the outer whorl without much change in strength; bullae or spines are absent. There are three or four somewhat rusiradiate moderately strong secondaries per primary on the first quarterwhorl of this fragment which arise by irregular bi- and tri-furcation and rarely by intercalation. They are restricted to the outer side of the whorl and project slightly before fading, leaving a narrow smooth band beside the keel. On the remainder of the fragment the secondaries extend weakly onto the inner whorl side and the costation becomes irregularly subfasciculate.

The septal suture is typically "hammatoceratid" with strongly retracted umbilical elements, narrow oblique U_2, deep E, and is intensively frilled.

Comparison.—The penultimate whorl at about 20 mm. diameter resembles *Eudmetoceras nucleospinosum, sp. nov.,* except for the even coarser ornamentation. The next whorl, however, is distinguished from that species by the persistence of the strong lateral tubercles or spines and the presence of well-defined strong primaries; fasciculation is also present but commences at about 40 mm. diameter (instead of 20-25 mm.). Up to this size the specimen resembles immature "*Parammatoceras rugatum*" (Buckman) of the "*P.*" *sieboldi* (Oppel) group, which is known to abound in the *L. murchisonae* Zone in Europe. The total appearance of the specimen, however, shows a perfect resemblance to Argentinian specimens described by Jaworski (1926) as "*Hammatoceras lotharingicum.*" It is more coarsely costate than its spinose near relative of

Eudmetoceras eudmetum and the associated *E. gerthi* (Jaworski) which also has markedly falcoid costae.

Eudmetoceras (Eudmetoceras) nucleospinosum, Westermann, sp. nov.
Pl. 66, figs. 3-5, Text-fig. 27a

Holotype.—Pl. 66, figs. 3a, b; well-preserved nucleus with one-fourth whorl fragment of mature phragmocone. Repository: U.W. 16633. (*Paratype:* Pl. 23, fig. 5; right external mold of one-fourth whorls of mature phragmocone. Repository: U.W. 16635.)

Locus typicus.—Shell locality A 22, north of mouth of Alai Creek, west shore of Wide Bay, Alaska Peninsula.

Stratum typicum.—Upper *E. howelli* Zone, *Eudmetoceras* zonule, Kialagvik formation.

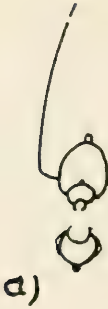
Age.—Late Lower Bajocian (late Aalenian), Upper *E. howelli* Zone.

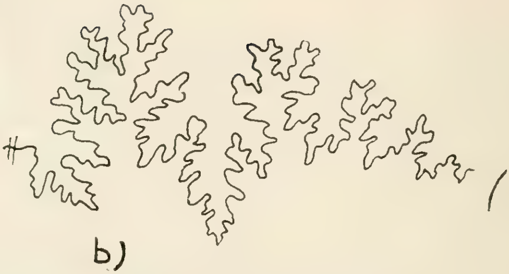
Diagnosis.—A compressed, involute species of *Eudmetoceras s.s.* with spinose nucleus and fasciculate costae on outer whorls; primaries reduced.

Material.—Two inner whorls and one external cast of the mature phragmocone from A 22.

Description.—The whorls of the nucleus at about 20 mm. diameter are moderately evolute and of broadly rounded subtriangular section. The hollow-floored keel is high and narrow. There are 5-6 strong lateral spines, somewhat clavate in the internal casts of one specimen, "impressed" in the umbilical wall of the subsequent whorl. The moderately strong secondaries are straight and markedly prorsiradiate. They arise by tri-furcation and probably also by intercalation. Primaries are obsolescent. This early ephibic stage resembles typical *Sonninia* ex gr. *S. sowerbyi* (Miller) from the *S. sowerbyi* and *O. sauzei* Zones and also spinose *Planammatoceras?* (*"Parammatoceras"*) ex gr. *sieboldi* (Oppel), such as *P. megacanthum* (Brasil), *P. baconicum* (Prinz), *P. diadematoides* (Meyer), *P. buxtorfi* (Renz), *"P. rugatum"* (Buckman), and *P. liebi* Maubeuge (1955a, pl. 6, fig. 1) [=*P. vaceki* Prinz, 1904, non Brasil, 1895] from the *T. scissum* (?), *L. murchisonae* and *G. concavum* Zones of Europe.

During further growth, however, there is an abrupt change of shape and ornament; the whorls become high-subrectangular with





Text-fig. 27a. Cross-section of *Eudmetoceras nucleospinosum, sp. nov.,* paratype, septate, loc. A22 in the Upper *E. howelli* Zone of Wide Bay; X 0.9.

Text-fig. 27b. Septal suture of *Eudmetoceras gerthi* (Jaworski), from Jaworski (1926, pl. 4, fig. 29), Cerro China (loc. 6), Argentina; X 1.7.

subparallel sides and steep umbilical wall with a narrowly rounded umbilical margin. After about 40 mm. diameter the whorls become much more involute. The costation consists of densely spaced essentially rectiradiate slightly flexuous, distally moderately projected ribs, which later fade near the umbilical edge. At least at the beginning of this stage elongated primaries can be distinguished. Most costae however, are continuous, and more or less clearly irregularly fasciculate somewhere on the inner whorl sides. There are only few clear intercalatories. The largest preserved phragmocone measures 90 mm. in diameter. The keel is high and hollow-floored up to the end. The ephibic phragmocone resembles *Eudmetoceras* such as *E. insignoides* (Quenstedt), *E. eudmetum* Buckman, *E. gerthi* (Jaworski), and *E. (Euaptetoceras) euaptetum* (Buckman) from the early *S. sowerbyi* Zone and *G. concavum* Zone of Europe.

The septal sulture shows a strongly retracted U_3 and a small oblique U_2, typical of the Hammatoceratinae. Grammoceratidae, Phymatoceratinae, and Sonniniidae with which it is in part homeomorphous, have straight sutures and a larger U_2.

Comparison.—The irregularly spinous ornamentation of this species resembles typical *Eudmetoceras* and *E. (Euaptetoceras).*

E. nucleospinosum is distinguished from all described species of *Eudmetoceras* in the absence of well-defined primaries on the inner whorls up to 20-25 mm. in diameter, and the presence of few strong spines only at this early stage. Consequently, before studying the largest of the three specimens, the author had assumed a closer relationship of this species to *"Parammatoceras,"* although in comparable forms the lateral tubercles or spines regularly remain on, or migrate to the middle of the sides of the mature whorls, and secondaries are defined to the outer flanks. In specimens studied, however, the costae become irregularly subfasciculate as is common in mature *Eudmetoceras.* Another diagnostic feature is the well-separated steep umbilical wall of the strongly compressed whorls.

Subgenus **EUDMETOCERAS (EUAPTETOCERAS)** Buckman, 1922

(Syn. (?) *Parammatoceras* Buckman, 1925)

Type species, *Euaptetoceras euaptetum* Buckman, 1922 [=*E. amaltheiforme* (Vacek) 1886].

Diagnosis.—An involute subgenus of *Eudmetoceras.* Primaries thin, long and of even strength, may be obsolescent, without nodes /spines, or with weak nodes-tubercles of even strength.

Eudmetoceras (Euaptetoceras) amplectens (Buckman), 1886

Pl. 67, figs. 2a-c; Pl. 68, figs. 1a-c; Text-figs. 28-29

1889. *Hammatoceras amplectens,* sp. nov. Buckman (Dorset), Q.J.G.S., vol. 45, p. 662.

1920. *Eudmetoceras amplectens* (Buckman), Buckman (Dorset), Type Am., III, pl. 180 A (holotype), pl. 180 B, fig. 1 (holotype), 2.

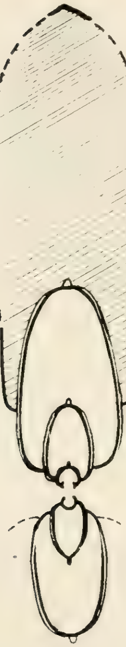
?1940. *Hammatoceras* sp. Althoff (Germany), Palaeontogr., vol. 85, B, p.38, last paragraph.

1955. *Eudmetoceras amplectens* (Buckman), Maubeuge (Swiss Jura), Mem. Suissse palaeont., vol. 71, p. 34, pl. 6, figs. 4, 5.

1957. *Eudmetoceras amplectens* (Buckman), Lieb (Swiss Jura), Ber. schweiz. palaeont. Ges., vol. 50, p. 580 (specimens seen).

Material.—One modestly preserved large specimen with fragmentary, somewhat compressed inner whorls and incomplete body chamber, from A 447 in the *E. howelli* zonule; one well-preserved totally septate internal mold with test remains from A 22 in the *Eudmetoceras* zonule.

Description.—Both specimens are almost certainly identical though their preservations differ. Late neanic and early ephibic whorls can be partially observed in the specimen from A 447. The whorl section is broadly ovate at 4-5 mm. diameter, at 8-10 mm. it is probably subcircular and possesses a thin sharp keel. These



Text-fig. 28. Composite cross-section of *Eudmetoceras* (*Euaptetoceras*) *amplectens* (Buck.); well-preserved phragmocone from loc. A22 in the *Eudmetoceras* zonule (Pl. 68, fig. 1), body chamber from loc. A447 in the *E. howelli* zonule of Wide Bay (Pl. 67, fig. 2); X 0.6.

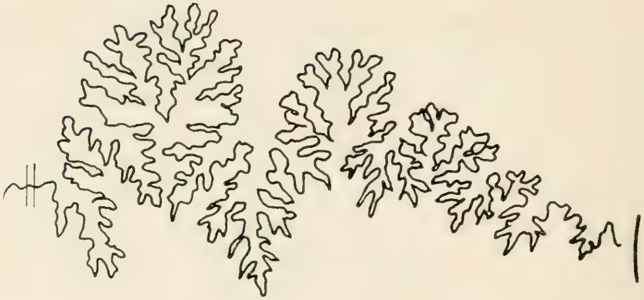
early whorls are evolute and rather thin. At 13 mm. the whorl section is somewhat compressed suboval and no costation is yet discernible, though some fine ornament may be present and obscured by the poor preservation. The other specimen, from A 22, shows well the whorl section of the phragmocone beyond 16 mm. diameter. The sides become flattened and converge only slightly except for the outer one-third which slopes to the rounded externside; the umbilical slope remains rather gentle and grades well rounded into the sides. As the height increases rapidly the whorls become more and more involute and compressed. The keel is high, well separated, and hollow-floored. Near the end of the phragmocone, at approximately 80 mm. diameter, the umbilical width is 10-12%.

At slightly over 20 mm. diameter there are densely spaced fine rectiradiate and only slightly projected, apparently regular costae on the outer half of the whorl. The inner half is smooth or broadly and bluntly undulated. The umbilical slope is always smooth. From 50-60 mm. diameter both specimens display slightly rursiradiate and markedly projected blunt secondaries which arise somewhat irregularly just before or on the centre of the sides where some irregular branching from highly obscure primaries may be present, only to be seen in oblique illumination. Subsequently the inner two-thirds of the sides become completely smooth and only short blunt moderately projected and regular costae, at a frequency of about 40 per halfwhorl, remain on the converging parts of the sides.

The phragmocones of the two specimens are at least 100 and 110 mm. in diameter, respectively. The fragment of the single body chamber from locality A 447 reaches a diameter of at least 165 mm. The umbilical seam egresses moderately and mainly the outer part of the whorl is rather strongly inflated. The externside grows acute with the reduction of the keel (Text-fig. 28).

The septal suture (Text-fig. 29) is intensively frilled with a linear saddle boundary. The umbilical elements gradually diminish in size and are somewhat oblique and slightly "retracted"; L is large, U_2 is only half the size of L. This suture is identical to that of the holotype, as figured by Buckman (1920).

Other occurrences and age.—The well-preserved phragmocone described here, perfectly resembles the holotype and topotypes from Bradford Abbas, Dorset, England, which were originally said to have come from the *G. concavaum* Zone (Buckman, 1889), later (*idem.* 1920) proposedly corrected to "Discites zone" (a subzone of the *S. sowerbyi* Zone). Though it is probably true that, as least, the host of the *Sonninia (Euhoploceras)* species, also originally described from the *G. concavum* Zone by Buckman (in "Inferior Oolite Ammonites"), originated in the only later separated "Discites zone" (see also Arkell, 1954, 1956), this is doubtful for the *Eudmetoceras* assemblage, especially for *"E. amplectens"* and *"E. euaptetum."* Both biostratigraphic units are thin almost everywhere in Dorset, often condensed, and generally of the highly fossiliferous, extremely shallow environmental type which suggests a good proportion of allochthon material (see also Bomford, 1948). Dorset is not regarded as the area where the accurate stratigraphic level of rare early Ba-



Text-fig. 29. External septal suture of *Eudmetoceras* (*Euaptetoceras*) *amplectens* (Buckman), at 77 mm. diameter, from loc. A22 in the *Eudmetoceras* zonule of Wide Bay (Pl. 68, fig. 1); X 1.5.

jocian species, such as *Eudmetoceras amplectens,* can with certainty be determined.

In the thick Lower Bajocian section near Lörrach, upper Rhine Valley, a typical *Eudmetoceras amplectens* was recently found by K. Hoffmann (priv. comm.) in the *G. concavum* Zone. The identity could be confirmed by a plaster cast of this specimen in the Naturhistorisches Museum Basel.

In the Basal Jura a "*Eudmetoceras* Zone/Subzone" was distinguished by Lieb (1954, 1957), between "Obere Concavazone" and "Disciteszone", at Sespen, near Oberfrick. In the Ghei section *E.* (*Euaptetoceras*) *amplectens* is relatively frequent in Lieb's (1951. 1954, 1957, p. 679) "*Eudmetoceras-Discites*-Zone", just above the beds with *Graphoceras concavum* and well below the *S. sowerbyi* Zone but occured supposedly together with *Hyperlioceras discites.* The author confirmed the specific identity at this occurrence in 1962 under the kind guidance of Dr. F. Lieb. Maubeuge (1955, p. 31, pl. 6, figs. 4, 5) described and figured two specimens near to this species but apparently transitional to the typical *E. amaltheiforme* from the *G. concavum* Zone of Le Coulou, Underviel, and Langmatt, also in the nothern Swiss Jura. They were supposedly associated with *E. amaltheiforme* (pl. 6, figs. 2, b, 3a, b).

According to Elmi (1962, Jura coll.) and Maubeuge (priv. comm.) our species occurs in eastern and southeastern France also in the *G. concavum* Zone and, significantly, below *H. discites* which, in turn, is said to appear there well below *Sonninia* spp.

Comparison.—E. amplectens is usually distinguished from *E.*

amaltheiforme in the absence of prominent primaries and of a sharp umbilical margin. However there appears to be some intergradation between both forms (Bradford Abbas sample) in both features. However, these "species" have not yet been found associated in thick, noncondensed sequences. Some weak primaries certainly may exist, mainly superficially, on *E. amplectens* although they rarely extend onto the umbilical margin. In *Strigoceras* cf. *klimakomphalum* (Vacek) from the *S. sowerbyi* Zone of Wide Bay and Argentina (*"Oppelia moerickei"*) the primaries extend onto the well-developed umbilical margin. Because of the strongly compressed involute whorls, the high hollow-floored keel and the obsolescent primaries *E. amplectens* is almost homeomorphous with early European *Strigoceras* and *Praestrigites* with more "lanceolate" whorl shape, which are generally included in the superfamily Haplocerataceae. The spiral fluting or strigation typical for Strigoceratidae may be totally absent in species of the early Middle Bajocian. R. Imlay (priv. comm.) also observed under the binocular some fine striae on some of the U.S.G.S. specimens of *S.* (?) cf. *klimakomphalum* from the *S. sowerbyi* Zone of Wide Bay. However, similar striae traces are also present on one specimen of *Eudmetoceras nucleospinosum*. All strigoceratids are distinguished in the typically discoidal involute inner whorls with subtriangular section while the species studies has rather evolute and rounded inner whorls.

Family **HILDOCERATIDAE** Hyatt, 1867

Subfamily **HARPOCERATINAE** Neumayr, 1875

Genus **PSEUDOLIOCERAS** Buckman, 1889

Type species, *Ammonites compactilis* Simpson *in* Buckman. 1889.

Pseudolioceras mclintocki (Haughton), 1858

1858. *Ammonites m'clintocki* (Haughton), Haughton (Canadian Arctic), Roy. Dublin Soc., Jour., p. 244, pl. 9, figs. 2-4.

Pseudolioceras mclintocki whiteavesi (White), 1889
Pl. 68, fig. 2; Pl. 69, figs. 1-6; Pl. 70, figs. 1-4; Pl. 71, figs. 1-2; Text-figs. 30-31.

1889. *Ammonites* (*Amaltheus*) *Whiteavesi*, sp. nov., White (Alaska Peninsula), U.S. Geol. Sur., Bull. 51, v.69 (499), pl. 13, figs. 1-5.

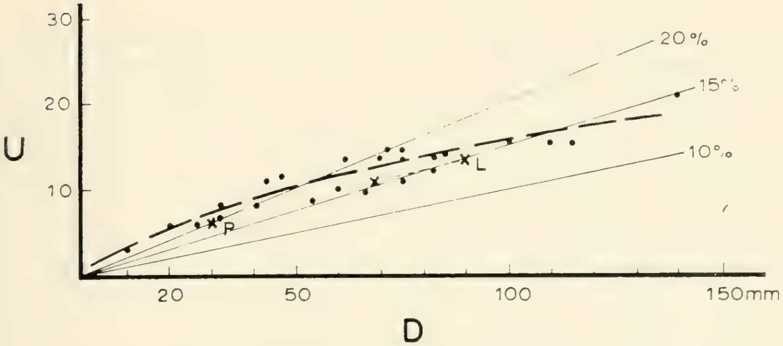
1945. *Harpoceras whiteavesi* (White), Kellum, Daviess, and Swinney (Wide Bay anticl.), U.S. Geol. Sur., Prelim. Rept.

? 1955. *Pseudolioceras whiteavesi* (White), Imlay (N. Alaska), U.S. Geol. Sur., Prof. Paper 274-D, p. 89, pl. 12, figs. 15, 16 [=? *P. mclintocki* s.s.]

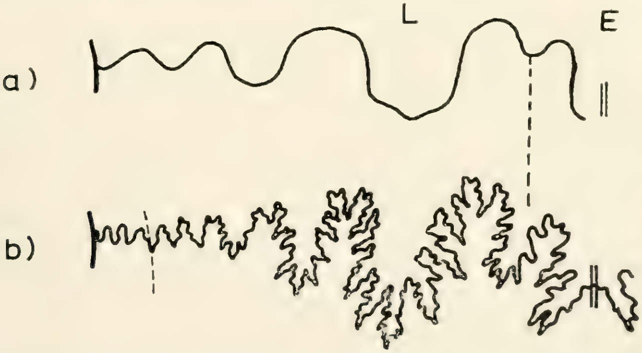
Lectotype.—Herewith designated, '*A. whiteavesi*' White, Pl. 55, figs. 1-3. (Plastotype here, Pl. 68, figs. 1a-c.) Repository: U.S.N.M., 132043.

Material.—Nine mature and two immature from A 443, L 285 (*howelli* zonule); one from A 454, one mature and one immature from A 449, A 8, nine mature + two immature from A 22, one mature from A 543, one immature (?) from A 11 (Middle and Upper *E. howelli* Zone).

Remarks.—Frebold (1957, p. 7, 1960, p. 20) recently redescribed *P. mclintocki* based on probable topotypes from near Point Wilkie on Prince Patrick Island, Canadian Arctic, collected by T. Tozer of the Geological Survey of Canada. The species occurs there abundantly and is sometimes accompanied by *Leioceras opalinum* (Rein.) and *Oxytoma jacksoni* (Pompeckj). The same fauna occurs also on nearby Melville Island while *L. opalinum* is missing from similar fanules of Mackenzie King Island *(op. cit.)*. Frebold (1960, p. 28) also suggested that the range-zones o*f L. opalinum* and *P. mclintocki* are not identical but rather overlap, though the mutual age relationship is yet unknown. The association of *P. mclintocki s.s.* with *Erycitoides* or *Tmetoceras,* however, has not yet been established. Frebold (1960, p. 4; 1961, pp. 7-8) recorded *Erycitoides* ex gr. *E. howelli* with *Pseudolioceras* of indeterminable specific identity from the Richardson Mountains, N.E. Yukon. In northern Alaska rather poorly preserved specimens of *Pseudolioceras* were referred to "*P. whiteavesi*" (Imlay, 1955), the only sufficiently known Bajocian species of this genus in America at that time. A study of Imlay's material showed, however, that an umbilical ridge is probably absent and that the costae are less flexuous on immature specimens than on *P. mclintocki whiteavesi.* The association with *Oxytoma jacksoni* (Pompeckj) may suggest an early Lower Bajocian age (*L. opalinum* Zone) for this fauna which would then correlate with the occurrence in the Canadian Arctic (Frebold, 1957). *Erycitoides* cf. *E. howelli* was reported from a nearby outcrop with *Pseudolioceras* cf. *mclintocki* of indeterminable subspecific affinity



Text-fig. 30. Scatter of umbilical width X diameter for *Pseudolioceras mclintocki whiteavesi* (White), with freely drawn "growth line". Some specimens measured at intervals (L=lectotype, P=paratype). The relative umbilical width decreases during growth from about 25 to 13 percent of the diameter. All from the *E. howelli* Zone of Wide Bay.



Text-figs. 31a, b. Juvenile and adult septal sutures of *Pseudoloceras mclintocki whiteavesi* (White), from loc. A22 in the *Eudmetoceras* zonule of Wide Bay. At diameter of a) 5 mm. (X 40) and b) about 60 mm. (X 2).

in only roughly the equivalent stratigraphic level, and *Tmetoceras* is only known isolated from a well (Imlay, 1955).

Based on well-preserved topotypes of White's *"Am. (Amaltheus) whiteavesi"* from Wide Bay ("Kialagvik Bay") and of Haughton's *"Am. m'clintocki"* from Prince Patrick Island as recently described and figured by Frebold (1957), both forms are here considered to be conspecific but subspecifically distinct. The diagnostic feature is the umbilical margin which is raised into a narrow ridge in the first form while it is not raised above the level of the sides in the second. This ridge was first regarded to be due to compaction of the sediment; however, further study has shown that most specimens are not deformed and that the features occur regularly in all adults of *Pseudolioceras* throughout the known Lower Bajocian sections of the Alaska Peninsula. Since all other characters are seemingly identical, the two forms respectively from south Alaska and from the Canadian Arctic Islands (and north Alaska ?) are regarded as chronological and (or ?) geographical subspecies.

P. mclintocki whiteavesi is slightly younger than *P. mclintocki s.s.* as is evident by the co-occurrence of *Leioceras opalinum* (Rein.) with the restricted species and *Tmetoceras, Abbasites,* and *Eudmetoceras* with *P. m. whiteavesi.*

Description.—The neanic stage of the shell has broadly suboval, moderately evolute whorls which become increasingly compressed. At about 2.5 mm. diameter the whorl section passes through subcircular into a high-suboval shape which becomes markedly triangular at 6-7 mm. The flanks are well rounded up to the umbilical seam until a steep umbilical wall with a sharp edge develops at about 15 mm. This edge, between 25 and 40 mm. (45 mm.) diameter, develops into a narrow ridge, essentially by the development of a depressed zone on the inner third of the whorl sides, analogous to the development of *Graphoceras concavum* (Sow.). The keel is originally solid and low and becomes high and hollow-floored at about 10 mm. D. The umbilicus is unusually large for *Pseudolioceras* though the shell becomes increasingly more involute. Up to a diameter of about 30 mm. the umbilical width is 20-25%; on medium-sized specimens this measure decreases to 14-21%, and on fully grown shells to approximately 13-15%. However, complete specimens are rare and no aperture was observed. The adult phragmocone varies in diameter between 65 and 115 mm.; the complete body chamber of over halfwhorl can be estimated at 100 to 150 mm. in diameter or more.

The typically falcate costation develops at a diameter of 12-15 mm. The costae are generally strong and rather widely spaced, though this varies considerably. The straight strongly prorsiradiate inner part of the costae is always clearly developed up to the umbilical ridge which is serrate on the test. The narrowly rounded backward-turn on the middle of the sides leads into the strongly concave thick outer part of the costae. They are always strongly projected and reach the near proximity of the high keel in a highly acute angle. A narrow smooth keel band is almost restricted to the internal mold. Intercalatories are rare and, if present, weak and restricted to the middle of the sides.

The proportions of the body chamber, as yet insufficiently known, are essentially as in the mature phragmocone with the seeming exception of some swelling mainly in the outer part of the whorls. There is, however, a marked change in costation, which becomes gradually falcoid and much less flexuous up to almost straight. The inner part of the costae fades and only fine growth striae remain, while the outer part becomes much more widely spaced and finally obsolescent forming low undulations. The end of the body chamber, not preserved on our specimens, was probably completely smooth.

The septal suture (Text-fig. 31) resembles that of *P. mclintocki s.s.* (Frebold, 1960, p. 20, pl. 8, fig. 3a, pl. 10) and the nearest related species, such as *P. beyrichi* (Schloenbach, 1865, pl. 27, fig. 10). Frebold's interpretation of the first deep lateral indentation as an extremely large accessory lobe of the E/L saddle (as opposed to a reduced L), is confirmed by ontogenetic studies.

Comparison.—This subspecies differs from *P. mclintocki s.s.* apparently only in the development of an umbilical ridge. *P. mclintocki* is larger than any other described species of *Pseudolioceras* though *P. beyrichi* (Schloenbach) 1865, from the Toarcian-Bajocian boundary of Germany, significantly the youngest species in Europe, comes close to it. *P. beyrichi* is distinguished from *P. whiteavesi* (*subspp.*) in the almost smooth inner flanks, in the whorl section with its maximal width much more externally, and the smaller umbilicus. Its near relation is evident in the strongly falcate costae which reach up to the keel. Another large relative is *P. lythense* (Young and Bird), 1828, from the Lower Toarcian of England, which approximates *P. mclintocki* in size and umbilical width, but differs in thicker whorls and the costation which is falcoid, less flexuous, and generally less projected and distally shorter. The many other described Toarcian species from Europe are much smaller and generally much more involute; their costation is weaker on the inner flanks or not typically falcate, and there are usually smooth keel bands.

Measurements.—

	D mm.	U%	W%
Lectotype	90	15.5	24.5
	68	15.5	26.5
Paratype	30	20	28

Subfamily **TMETOCERATINAE** Spath, 1936

Genus **TMETOCERAS** Buckman, 1892

Type species, *Am. scissus* Benecke, 1865.

The genus comprises the subgenera *Tmetoceras (Tmetoceras)* and *T. (Tmetoites), subgen. nov.,* the macroconchs and the microconchs, respectively.

Dimorphism.—The co-occurrence of small ammonites with lappets and large ones with simple aperture resembling one another in other respects is commonly, though not by all authors,[8] regarded as a result of sexual dimorphism and has been observed within the great majority of Middle and Upper Jurassic families. Thus Arkell (1957, p. L 90), in the latest thorough revision and diagnosis of most Jurassic genera, stated that there are only few families of this age in which no lappets have been reported, such as the Macrocephalitidae. Until the new findings described herein, several subfamilies of the Hildoceratidae, including Tmetoceratinae, and at least typical Hammatoceratidae, had to be added to this group.

From both latter families microconch species are described which at least in part appear to resemble co-occurring macroconch species on the specific level while others apparently do not. Significant results, however, can only be based on large hypodigms still wanting. Although there can be no doubt that microconchs usually represent adults and not immatures of macroconchs (Westermann, 1956, p. 17; Arkell, 1957, p. L87) careful consideration has to be

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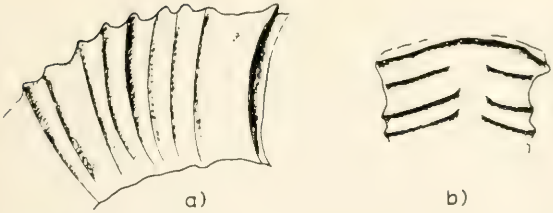
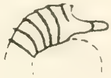
[8] The writer (1954, p. 68; 1956, p. 17) stated his disbelief in the general acceptance of sexual dimorphism for most of these morphic pairs because the resemblance is rarely on the specific level. This can be formulated differently: if micro- and macroconch differ significantly also in other characters but size and body chamber, such as for example the style of costation or the whorl shape of inner whorls, then their specific relationship cannot be established on morphological grounds. However, the possibility of costation being strongly involved in dimorphism has just recently arisen in studies of goniatites (Walliser, summary, 1962).





Text-figs. 32a, b. Aperture of *Tmetoceras scissum* (Benecke), large complete specimen from loc. 48 A_1-107 (21247) in the basal Kialagvik formation of Wide Bay, approximately 100 m. below base of *E. howelli* Zone. a) Right lateral and b) external view (Pl. 72, fig. 1); X 1.2.

Text-fig. 33. Aperture of *Tmetoceras* (*Tmetoites*) *tenue* (?), *sp. nov.*, post-mortem compressed specimen from loc. B128 in the (Upper) *E. howelli* Zone of Puale Bay (Pl. 73, fig. 2); X1.

given in interpreting those specimens which show strongly rythmical ("segmental") growth by the presence of constrictions and similar features. Unrestricted generalisations may be falacious. If the body chamber of the microconch does not differ significantly from the inner whorls of the macroconch, except of course for the aperture, and if the constrictions of these inner whorls show curved growth lines preceded by increasingly convex costae, like on the body chamber of the microconch, there remains some possibility that the lappets were indeed periodically resorbed or overgrown. Such a development would leave evidence similar to that shown on the microconch specimens of *T.* (*Tmetoites*) *tenue* (Plate 73, fig. 5) and the macroconch specimen *T. kirki flexicostatum* (Plate 72, fig. 10). Under the assumption that these microconchs are fully grown the mentioned specimen of *T. tenue,* which has strongly convex lira on a former constriction, must have possessed lappets, though possibly short, already once before at an earlier stage, and at least some macroconch specimens of *T. kirki* must have had the tendency for lateral lobature, which is the beginning of lappet development, at adolescent growth stages. Based on the same considerations the specimen of *T. tenue* figured on Plate 73, figure 1, may have been immature because its apertural features preserved resemble those to be inferred to have existed on the specimen of figure 5, at a stage when the constriction, now in the middle of the body chamber, was at the aperture. On the other hand, the small specimen of figure 2 bearing large lappets and strongly convex last costae, appears fully grown. However, it has also to be taken into account that the small lappet shown in figure 1 may have been in the process of growth or that it has inconspicuously broken off postmortally along the growth lines, as probably occurred also on lappets of other genera (Westermann, 1956, p. 19).

The only microconchs of *Tmetoceras* figured previously appear to be "*Helicoceras alpinum*" Thalmann (1924) from the Aalenian (Lower Bajocian) of the Swiss Jura and "*T.* aff. *Gemmellaroi* Fucini" described by Burckhardt (1903) from Argentina.

In the Upper *E. howelli* Zone of Wide Bay a number of "dwarf" *Tmetoceras* microconchs bearing lappets occur together with *Tmetoceras* macroconchs of two to four times their size. As usual, there is some difficulty in assigning specific equivalence of contemporaneous micro- and macroconchs and the typical distantly costate *T. tenue* clearly appears to have no macroconch equivalent. However, a similar (phylogenetic ?) trend is probably present in both subgenera, *i.e.* the progressive thinning and, partly, also the reduction of spacing of the costae. It is to be kept in mind that the faunas are incompletely represented and that the Upper *E. howelli* Zone, although more than 100 m. thick, probably represents only a relatively short time interval. From the basal part of this interval (Shell locality A 8) came the coarsely costate specimens described as *Tmetoceras* (*Tmetoites*) *tenue* (?) and *T.* (*Tmetoites*) cf. *T. alpinum* (Pl. 72, figs. 7, 11) which were associated with *T.* (*Tmetoceras*) *kirki s.s.* From the uppermost beds came the typical *T.* (*Tmetoites*) *tenue* and the extremely densely costate *T.* (*Tmetoites*), *sp. nov.,* the latter one of which strikingly resembles *T.* (*Tmetoceras*) *kirki flexicostatum* found in the same bed (*T. tenue-flexicostatum* zonule). But *T. tenue* does not resemble any known macroconch though there is much variation in the characteristic costae features probably with some overlap to *T. kirki s.s.* which may persist up to the topmost beds of the *E. howelli* Zone.

Subgenus **TMETOCERAS (TMETOCERAS)** Buckman, 1892

Tmetoceras (Tmetoceras) scissum (Benecke), 1865

Pl. 72, figs. 1a, b, 2a, b; Text-figs. 32, 34

1865. *Ammonites scissum* Benecke (Südalpen, Cape St. Vigilio), Geog. Pal. Beitr., 1, p. 170, pl. 6, figs. 4a, b.

1874. *Ammonites Regleyi* Thiolliere, M., Dumortier, Depots Jurass. Bassin du Rhone, vol. IV, p. 119, pl. 31, figs. 8, 9 [photo of holotype, as *T. scissum in* Roman and Boyer, 1923, pl. 6, fig. 6].

1878. *Cosmoceras Regleyi* (Thioll), Gottsche (Argentine Cordillery), p. 16, pl. II, fig. 3. [sp. juv.?].
1883. *Cosmoceras Hollandae* Buckman (Dorset), Proc. Dorset Field Club, vol. IV, pl. 1, fig. 2, non "*T. Hollandae* var." pl. 2, fig. 2; [refigured in Buckman, 1892, pl. 48, figs. 4-7].
1886. *Parkinsonia Regleyi* (Thioll.), Gregorio (Monte Erice, Sicily), Mem. R. Acad. Sci. Torino (2), vol. 37, pl. 2, fig. 9 [sp. juv.].
1886. *Simoceras scissum* (Benecke), Vacek (Cape St. Vigilio), Abh. K.K. Reichsanst., 12, p. 103, pl. 16, figs. 15-17.
1892. *Tmetoceras scissum* (Benecke), Buckman (Inf. Ool. Am.), Pal. Soc. vol. 45, p. 273, pl. 48, figs. 1-9.
1898. *Tmetoceras circulare* Buckman (Inf. Ool. Am. Suppl.), Pal. Soc. vol. 52.
1904. *Parkinsonia* (*Tmetoceras*) *scissa* (Benecke), Prinz (Bakony), Mitt. K.K. Ung. geol. Anst., 15 (pl. 16, fig. 2a, b), pl. 20, fig. 3a-c.
1923. *Tmetoceras scissum* (Benecke), Roman and Boyer (Lyonnais), Trav. lab. Geol. Lyon, IV, p. 38, pl. 6, figs. 6, 7, 8? [sp. juv.?].
1933. *Tmetoceras scissum* (Benecke), Arkell, Jurassic System in Gr. Britain, pl. 33, fig. 4.
1954. *Tmetoceras recticostatum* Sato (Japan), Jap. J. Geol. Geogr., 24, p.118, pl. 13, pars.
(?) 1955. *Tmetoceras scissum* (Benecke), Maubeuge (Swiss Jura), Mem. Suisse Pal., p. 17, pl. 2, fig. 1a-c.

Diagnosis.—An almost advolute species of *Tmetoceras s.s.*, subcircular to moderately compressed suboval whorl section and strong rectiradiate costae, externally always broadly interrupted, and prominent. Septal suture relatively complicated.

Age (general).—Probably at least throughout early Early Bajocian (Aalenian), but "acme" clearly in upper *L. opalinum* range-zone in Europe, *i.e.* the *L. comptum* Subzone or *T. scissum* Zone (Rieber, priv. comm.).

Material.—One large complete specimen, partly laterally deformed; two large body chamber fragments as internal molds and umbilical impression, probably of single specimen; both from $18A_1$-107 (21247), basal part of Kialagvik formation, 80-120 m. below base of *E. howelli* Zone. Deformed (?) fragments of probably single specimen from L 285, basal *E. howelli* Zone; one (?) incomplete specimen and (?) body chamber fragment, both deformed internal molds with test remains, and one small lateral imprint from A 86, Middle *E. howelli* Zone. All Wide Bay, Alaska Peninsula.

Taxonomy and constrictions.—The identity of *Tmetoceras scissum* and *T. regleyi* (Dumortier), 1874[9] supposedly distinguished essentially only in the respective presence or absence of constrictions, was originally advocated by Buckman (1892, p. 273). generally criticized as a typical taxonomical "splitter", though the same author later (1898) separated both species on other grounds. The English and French representatives of *Tmetoceras* are generally smaller than the Mediterranean forms with constrictions typically developed on the last 1 to 1½ whorls. Buckman (1892, p. 273) believed that this stage had not been reached in the *"regleyi"* forms. However, English specimens do frequently exceed 25-35 mm. in diameter at which stage constrictions are clearly present on typical *T. scissum* according to the figures given by Benecke (1865, pl. 6), Vacek (1886, pl. 16), and Prinz (1904, pl. 20). In checking through the Geological Survey of Great Britain and British Museum (Natural History) collections in London in summer 1962 the writer observed three large body chambers among a total of approximately 20 *Tmetoceras* specimens from Dorset which had indisputable constrictions strongly developed on two of them. These specimens were probably known to Buckman but remained undescribed presumably because of their incomplete preservation. Another specimen from Dorset bearing two clearly marked constrictions at 30 and 40 mm. diameter, respectively, is in the Royal Ontario Museum, Toronto, Ontario.

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[9] The first description of the species is from Dumortier (1874, p. 119), who attributed the name to Thiolliere based on an unpublished manuscript. Dumortier (*loc. cit.*) wrote: "unhappily our friend was surprised by death before he was able to publish the description." Consequently the first describing author is Dumortier and not Thiolliere as often inferred.

A similar case of supposed absence of constrictions was reported from British Columbia by Frebold (1951) who discriminated *Tmetoceras regleyi* from *T. scissum* solely on absent constrictions. However, on the only figured body chamber (Pl. 57, fig. 1) several strong constrictions are clearly present, also observed on a rubber mold of this specimen kindly furnished by Dr. Frebold. Also some relatively small specimens of *"T. recticostatum"* Sato (1954) from Japan, here at least largely included in *T. scissum,* appear to be constricted.

Tmetoceras scissum was reported, but neither described nor figured, to occur together with *T. regleyi* in the Swiss Jura Mountains by Lieb (1951, 1954) and "typical" *T. scissum* was described from the same area by Maubeuge (1955, pl. 2, fig. 1) without mention of constrictions. According to the figure some weak constrictions appear to be developed on the ultimate whorl of the large specimen. Lieb (priv. comm, 1962) based his specific discrimination on dimension and costation characters following Buckman (1898). A restudy of the relevant specimens by the writer in summer 1962, however, revealed that the Swiss form shows a mode of morphological variation resembling the English sample mentioned above and that consequently also the known Swiss *Tmetoceras* belong to the single species *T. scissum*.

In the collections of the University of Lyon, among Dumortier's original material from the type locality of *T. regleyi* at Villebois (Ain) in the southern French Jura, is a specimen labelled "*Tmetoceras regleyi* Thiollier" which has typical constrictions and is in any respect a typical *T. scissum*.

Constricted specimens of *Tmetoceras* were also reported from Espinazito Pass, Argentina (Tornquist, 1898, p. 13, 14), but only a small apparently incomplete unconstricted specimen probably belonging to *T. scissum* was figured (Gottsche, 1878, p. 16, pl. 2, fig. 3); again, significantly found associated.[10]

The fauna from Wide Bay includes seven more or less complete shells of *Tmetoceras s.s.* from four horizons, one of them below and three in the upper part of the *E. howelli* Zone. The single large and complete *T. scissum* bears constrictions from at the most 35 mm. diameter up to the aperture (Pl. 72, fig. 1); the two body chamber fragments of another specimen from the same lot show three strong constrictions, the first of which corresponds to approximately 35 mm. diameter (fig. 2); one specimen of *T. kirki* has constrictions only on the body chamber (fig. 4), another one only on the phragmocone from 14 mm. to 20 mm. diameter (fig. 10). The presence or absence of constrictions often appears to be a matter of arbitrary decision because they simply consist of a deepening and broadening or broadening of the intercoastal spaces which, in itself, are generally of extraordinary depth. This agrees with the (adult) apertural constriction which is of simple circular shape on the fully preserved specimen of *T. scissum* (Pl. 72, fig. 1). The constrictions are rarely continuous over the externside except for the strong ones which are mostly the last one to three developed in approaching the

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[10] While this paper was in press two fragments of large typical *Tmetoceras scissum,* strongly constricted, from the "Aalenian" (? Los Molles formation) of Picun Leufu in Neuquén, Argentina, were received through the kind auspices of Dr. Camacho (Repositary: La Plata University, Dept. Geology, 0149)

adult aperture (see also Vacek, Prinz, *loc cit.*). Consequently only especially strong constrictions are not obscured by the costation (strictly speaking, plication) on the internal mold, mainly if post-mortem deformation has taken place. It may, therefore, be assumed that the status of constriction development is not of a present-absent, *i.e.* qualitative nature, but of the quantitative type. They are always present, at least potentially, at some ontogenetic stage, though of highly differing degree of strength probably of an intergrading quantitative series. There may well be some yet unknown environmental factor involved in the development of constrictions since they reflect "segmental", discontinuous growth.

There is a complete morphological intergradation between advolute subcircular and distantly costate whorls, *i.e. Tmetoceras circulare* Buckman 1898, and markedly involute, compressed, and densely costate whorls, *i.e. T. regleyi* (Dum.), with intermediate "typical" *T. scissum* (Ben.), in samples from single chronodemes studied by the writer in Europe in 1962, including the one collected at Burton Bradstock, Dorset. This fact was already noted by Buckman (1892), and it follows that these names only designate morphotypes.

Tmetoceras scissum and *T. regleyi* are, therefore, considered variants of a species which displays much and regionally somewhat differing (partly phenotypic ?) variation.

Age.—The total vertical range of *T. scissum* as here defined is certainly not restricted to the *T. scissum* Zones of the European standard zonal sequence as presented by Arkell (1956, 1957). The *T. scissum* Zone is not equivalent to the *C. sinon* zone or *"Sinon-Tolutaria* zone" but to the upper *L. opalinum* range-zone, the *L. comptum* Subzone (*costosum* zone *auct.*)[11] The *"scissum* bed" at Burton Bradstock dated as "top of the *opalinum* zone" already by Buckman (1892, p. 273). The writer found in the same bed at this locality a typical assemblage of the *L. comptum* Subzone: large *Leioceras opalinum* (Rein.) and *L.* ex gr. *L. comptum* (Rein.)—*costosum* (Quenst.) beside *T. scissum*. Buckman (*loc. cit.*) also stated the occurrence of *T. scissum,* of the *"regleyi"* morphotypes, from the lower *L. murchisonae* Zone, though based on insufficient stratigraphical evidence. The same stratigraphical position holds for the excellent Swiss sections in the Jura Mountains described by Lieb (1954, 1957) where a similar assemblage is clearly overlain by beds with *Costileioceras sinon* (Bayle) if there is no condensation. This sequence also exists in the Swabian (Rieber, 1963) and in the French Jura (Enay and Elmi, 1960, 1962).

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[11] See footnote 3.

The first occurrence of *Tmetoceras* cf. *T. scissum* in Europe is probably already in the *"meneghinii"* zone (approximately equivalent to the upper *L. jurense* Zone of N.W. Europe), upper Toarcian, of the central Apennine (Fossa-Mancini, 1915), southern Switzerland (Renz, 1920), and Portugal (Perrot, 1955), in association with *Dumortieria* or *Catulloceras* (see also Donovan, 1958). The writer collected *Tmetoceras* aff. *T. scissum* (possibly intermediate to *Catulloceras)* in beds identical with or only a few feet above beds carrying *Dumortieria* near Buggio, Umbria, and observed a complete morphological intergradation between *Catulloceras* and *Tmetoceras* within a supposed chronodeme collected by C. Renz in the Canton Tessin, Switzerland, now in the Basle Museum (kindly shown to the writer by C. Renz, in 1962).

The latest European occurrences of *Tmetoceras* cf. *T. scissum* were reported from the *L. murchisonae* Zone of Caen, Calvados, France, by Brasil (1893) and from supposedly Middle Bajocian beds of the Central Apennine (Fossa-Mancini, 1915; see Donovan, 1958). M. Rioult kindly demonstrated the absence of Bajocian beds older than the *L. murchisonae* Zone in Brasil's locality to the writer in 1962. However, the specimens have not been well enough described or figured and their specific identity is dubious. Bomford (1948) reported rare *"Tmetoceras* sp. juv. aff. *scissum"* from the (upper) *L. murchisonae* Zone and, possibly, *G. concavum* Zone of Beaminster, Dorset, England. The writer was unable to find any new specimen while re-collecting this section in 1962 but did restudy Bomford's youngest specimen from "bed 4." It is a small form belonging to a new species possibly of the subgenus *Tmetoceras (Tmetoites),* characterised by compressed rectangular advolute whorls bearing densely spaced fine costae which are externally interrupted by a broad smooth band.

In the Andes of Argentina, at the Espinazito Pass, *Tmetoceras* cf. *T. scissum* occurs just below beds of the *S.sowerbyi* Zone

(Gottsche, 1878) (footnote 10) and is said to be associated with *Graphoceras* cf. *G. concavum* (Sow.) (Tornquist, 1898). Though the specific identity of the latter is uncertain from the description (Arkell, 1956, p. 585), H. Rieber, the authority on the Swabian Graphoceratidae (priv. comm., 1962), does not deny Tornquist's identification and firmly believes that it represents the *G. concavum* Zone (or possibly the *H. discites* Subzone of the *S. sowerbyi* Zone). This is the only described occurrence of *Tmetoceras* cf. *T. scissum* as late as the *G. concavum* Zone, significantly directly underlying the *S. sowerbyi* Zone just as at Wide Bay. Graphoceratidae are extremely rare in the Americas, and none has yet been reported from North America.

From Oregon Lupher (1941) reported "*Tmetoceras* n. sp." and "cf. *T. scissum*" from near the base of the Weberg formation. In the upper range of their occurrence they are said to be associated with *Praestrigites* cf. *P. deltotus* (Buckman), typical for the *G. concavum* Zone of England, and "*Sphaeroceratids* n. gen., similar to *Emileia*", possibly belonging to *Erycites* or *Abbasites*. This sequence is overlain by beds containing *Sonninia (Euhoploceras), Witchellia,* and *Docidoceras,* all typical for the *S. sowerybi* Zone. The re-study of Lupher's section by the writer in 1963 confirmed the stratigraphic sequence and the representation of the *S. sowerbyi* Zone by the upper Weberg formation but failed to yield any ammonoids from the lower part of the Weberg formation from which Lupher reported the *Tmetoceras* specimens.

The only Canadian occurrence of *Tmetoceras scissum* is known from the Hazelton group in Whitesale Lake map area in British Columbia, where it is found stratigraphically isolated, and only tentatively supposed "'*Polymorphites*' cf. *senescens* Buckman", probably a pathological specimen of *Tmetoceras,* is associated (Frebold, 1951).

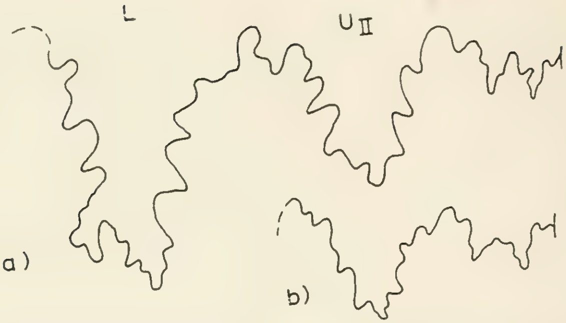
Imlay (1952, 1955) reported *Tmetoceras* sp. juv. from the Arctic slope of Alaska, where it probably occurs in the same interval as *Erycitoides* cf. *E. howelli* (White) and *Pseudolioceras mclintocki* (White), as on the Alaska Peninsula.

At Wide Bay *T. scissum* occurs in the *T. scissum* "zonule" 80-120 m. below the *E. howelli* zonule *i.e.* the lowest known range of the *E. howelli* Zone, in beds of post-Toarcian age lacking other ammonites, and probably also in the Lower and Middle *E. howelli* Zone. Here occur also rare *Abbasites, Erycites,* and *Eudmetoceras (Euaptetoceras) amplectens* (Buckman), all typical for the late Early Bajocian (late Aalenian) and the latter probably also for the lowermost *S. sowerbyi* Zone of northwest Europe.

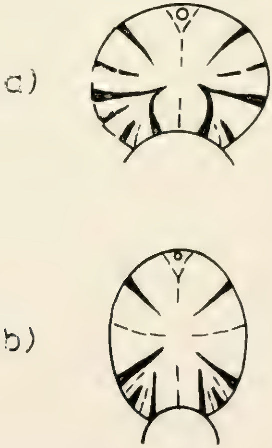
Thus the three occurrences of *Tmetoceras* in the Americas *i.e.* Espinazito, central Oregon, and Wide Bay, which can tentatively be dated according to the European zonal succession, appear to be of late Early Bajocian (late Aalenian) age.

In Japan *Tmetoceras scissum* [*"T. recticostatum"* Sato, 1954a] occurs in the *Hosoureites* and *Hammatoceras* zones (Sato, 1958), the former including forms here tentatively suggested to belong to *Pseudolioceras* (Sato, 1954, pl. 13, figs. 11?, 12, 13), the latter typical *Planammatoceras* and *"Parammatoceras"* auct. of the *L. murchisonae* Zone (Santo, 1954b). The range of *T. scissum* is, therefore, probably from the *L. opalinum* Zone to the *L. murchisonae* Zone.

Description.—The whorls of the two single large specimens are almost advolute and change in section from moderately compressed oval of the last phragmocone whorl, only preserved on the complete specimen, to subcircular at the body chambers of both specimens. The strong costae are straight and radial throughout development. ending abruptly in elongated projections beside the median groove. On the last two whorls of the phragmocone the number of costae increases from 17 to 21 per halfwhorl, remaining extremely stout with deeply rounded interspaces on test and internal mold. The body chamber is only one-third whorl long on the complete specimen. Four or five constrictions are moderately developed on the last whorl of the phragmocone, the first one possibly at 26 mm. but certainly at 35 mm. diameter. They are arranged in irregular quadrants, and probably all restricted to the whorl sides, and marked by deepening of the interspaces only. The constrictions are strongly developed and continuous on both body chambers, respectively. On the complete specimen the costae become markedly curved, projected, and approximated at about 2 cm. before the peristome. The aperture has an especially strong and broad constriction followed by a markedly raised subcontinuous collar. The peristome is again somewhat constricted and probably of simple shape, though its external part is incomplete. The total diameter is between 50 and 65 mm.



Text-figs. 34a, b. Incomplete septal sutures of *Tmetoceras scissum* (Benecke), single specimen from loc. 48 A_1-107 (21247) in the basal Kialagvik formation of Wide Bay. a) At 35 mm., b) at 45 mm. diameter, U_2 large and frilled (Pl. 72, fig. 1).



Text-figs. 35a, b. Fluting of immature septa of *Tmetoceras* spp., Upper *E. howelli* Zone of Wide Bay; saddle axes indicated by solid lines, lobe axes by dashed lines. a) *T. (Tmetoites) tenue, sp. nov.*, at 3 mm. diameter, b) *T. (Tmetoceras)* cf. *T. kirki, sp. nov.*, at 8 mm. diameter. Both magnified.

Comparison.—There is a complete resemblance of the specimens studied with "typical" *Tmetoceras scissum* as figured from Cape St. Vigilio by Benecke and Vacek (see synonymy).

The writer originally included all macroconch specimens from Wide Bay in this species. Extensive study and collecting of the

European representatives of this species in summer 1962, however, resulted in the specific discrimination of most representatives from the *E. howelli* Zone as *T. kirki, sp. nov.* This is based on the generally weaker irregularly curved costae, their obsolescent "ventral" groove which may be replaced on the body chamber by subcontinuous chevrons, and finally the even more simplified septal suture of the latter.

Measurements.—

	D mm.	W%	H%	U%	P
Pl. 29, fig. 1 (aperture)	65	27.0	26.1	51.5	25

Tmetoceras (Tmetoceras) kirki Westermann, sp. nov.
Pl. 72, figs. 4-6, ? 7, 8-10; Text-figs. 35, 36

Holotype.—Pl. 72, figs. 4a, b; well-preserved internal mold of almost complete specimen, undistorted, last costae pathological. Repository: U.W., 16648.

Locus typicus.—Shell locality A 8, Moose Creek-Mt. Kathleen section, Wide Bay, Alaska Peninsula.

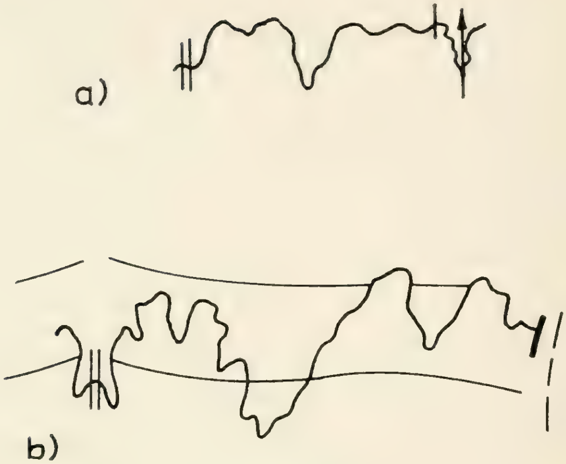
Stratum typicum.—Upper Kialagvik formation, near base of Upper *E. howelli* Zone.

Derivatio nominis.—For Mahlon V. Kirk, Paleontologist, Shell Oil Company, Seattle, Washington (see preface).

Diagnosis.—An advolute to slightly involute species of *Tmetoceras s.s.*, moderately to densely spaced more or less irregularly flexuous costae, externally only narrowly interrupted and sometimes subcontinuous, strongly compressed oval whorls, and a very simplified septal suture.

Age.—Upper *E. howelli* Zone, late Early Bajocian (late Aalenian), probably equivalent to the *G. concavum* Zone.

Remarks.—As stated above, this species was originally thought to belong to *Tmetoceras scissum* but finally discriminated, based on the features given in the diagnosis. The septal suture studied only just recently finally gave convincing evidence (Text-figs. 34-37). Marked constrictions are missing on most specimens although diameters appear large enough. They are, however, present



Text-figs. 36a, b. Septal sutures of *Tmetoceras kirki, sp. nov.,* from Upper *E. howelli* Zone of Wide Bay. a) *T.* cf. *kirki,* complete immature suture at 8 mm. diameter corresponding to septum of Text-fig. 35 b. b) Holotype, at 28 mm. diameter. Both magnified; U_2 small and simple.

on the body chamber of the holotype and, remarkably, only on the nucleus of another specimen (Pl. 72, fig. 10). Constrictions appear to vary strongly and irregularly, possibly with little genetic dependence, and are here consequently not regarded as of much taxonomic value.

The whorl section is more compressed and externally more narrowly curved than in at least most examples of *T. scissum.* The septal sutures of three specimens, *i.e.* all which could be observed, are simpler than in the complete specimen of *T. scissum* and than sutures figured by other authors of any *Tmetoceras* macroconch of comparable size. *Tmetoceras kirki* is only known from the upper part of the *E. howelli* Zone of Wide Bay, and two stratigraphical subspecies are distinguished. There is a clear evolutionary trend in the intensification of the specific "diagnostic" characters, *i.e.* away from *T. scissum*-like ancestralship, ending in *T. kirki flexicostatum, subsp. nov.*

Tmetoceras (Tmetoceras) kirki kirki Westermann, sp. et subsp. nov.
Pl. 72, fig. 4-6; Text-figs. 35, 36.

Diagnosis.—A subspecies of *T. kirki* with moderately spaced strong costae which usually become strongly flexuous only on the body chamber.

Material.—The holotype and two incomplete imprints, Shell locality A 8, basal Upper *E. howelli* Zone, Wide Bay.

Description.—The holotype is the only well-preserved specimen of the species, but the significant costae features are evident also in the postmortem more or less strongly compressed specimens. The fact that the costae of many similarly deformed European *T. scissum* remain straight and, further, that the costae are flexed also on undeformed whorl sectors of *T. kirki s.l.* are all evidence for the originality of this flexure.

The shell is only of medium size (approximately 45 mm. diameter) and consists of almost advolute or only slightly involute, rather strongly compressed oval whorls, throughout the neanic and ephibic development (juvenile to mature, from about 3 mm. diameter to the aperture). The externside is narrowly rounded to subacute but may be partly weakly grooved. There are 12 to 16 moderately strong, sharp, more or less markedly irregularly curved, and often somewhat differently spaced costae per halfwhorl on the inner whorls up to about 20 mm. diameter. Single costae may be obsolescent resulting in greatly enlarged interspaces which may be called constrictions, although they do not "constrict" the whorl by a deepening of the interspaces and are externally discontinuous. Subsequently, during maturation, the costae frequency increases to about 20 to 24 per halfwhorl and the curvature becomes obvious. On the body chamber the (intercostal) whorl section becomes subacute and the costae more projected until they finally become continuous in chevrons on the holotype. There are several strong constrictions on this almost entire body chamber measuring halfwhorl in length. The strong costae anomality at the end is almost certainly due to a bite injury by a scavenger.

The septal suture of the holotype (Text-fig. 36) is characterised by a small U_2 ("second lateral lobe") and the almost nonexisting subdivision of the whole inner part of the external suture, commencing with the tip of L.

Comparison.—*T. kirki* proper is morphologically intermediate, regarding the mode of costation, between *T. scissum* with strong straight costae and *T. kirki flexicostatum* with weak strongly flexuous costae.

Measurements.—

	D mm.	W%	H%	U%	P
Holotype (body ch.)	43	25.5	29	46.5	22
(phragm.)	31	27	32	45	19
"	21	31	39	39	16
"	14.5	27	34	ca.40	14

Tmetoceras (Tmetoceras) kirki flexicostatum Westermann, sp. et subsp. nov. Pl. 72, figs. 8-10; Text-fig. 37

Holotype.—Pl. 72, fig. 8; almost complete internal mold. postmortem compressed at differing degrees, some test remains. Repository: U.S.N.M., 132050.

Locus typicus.—U.S.G.S. Mesozoic locality $48A_1$-109 (21254), on tributary of Short Creek, Wide Bay, Alaska Peninsula.

Stratum typicum.—Upper Kialagvik formation, *E. tenue-flexicostatum* zonule at top of *E. howelli* Zone.

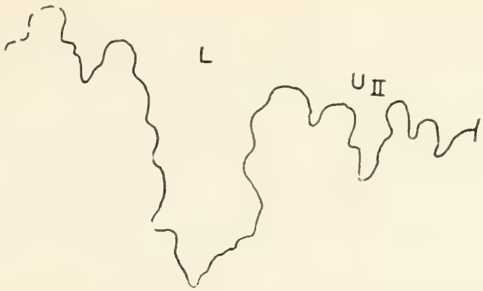
Derivatio nominis.—Selfexplanatory.

Diagnosis.—A subspecies of *T. kirki* with densely spaced strongly flexed costae.

Age.—Late Early Bajocian (late Aalenian), uppermost *E. howelli* Zone, *T. tenue-flexicostatum* zonule; probably equivalent to the European *G. concavum* Zone.

Material.—The holotype; one right imprint of large almost complete specimen, somewhat distorted and compressed, from L 154, one well-preserved phragmocone, internal mold, and one fragmentary left imprint, from A 11. All from *T. tenue-flexicostatum* zonule at top of *E. howelli* Zone, Wide Bay.

Description.—The advolute or highly evolute whorls are compressed-oval in section. The umbilical width of the shell is approximately 48-50 percent of the diameter which reaches the large size of 55-60 mm. There are 14 to 20 densely spaced thin and sharp costate per halfwhorl on the nucleus commencing at 3-4 mm. diameter and increasing to 25-30 on the last whorls. The costae are always markedly and often strongly curved throughout morpho-



Text-fig. 37. Mature septal suture of *Tmetoceras kirki flexicostatum, sp. et subsp. nov.,* holotype, from the *T. tenue-flexicostatum* zonule of Wide Bay, at 36 mm. diameter. Magnified.

geny, generally with lateral convexity. The degree of curvature is often arranged in 1/3 to 1/4 whorl cycles; in each whorl segment the costae become increasingly convex and the last costa often becomes obsolescent representing a kind of constriction, similar to that sometimes seen on *T. kirki s.s.* Although compressed, the body chamber of the holotype shows a narrowing and finally almost disappearing interruption of increasingly projected costae.

The septum is well preserved on the specimen of Plate 72, figure 10. The "centrally supported" structure is dominated by a pair of cruciform saddle and lobe axes. The suture is extremely simple with strongly reduced U_{II} and U_{III} ("2d and 3d lateral") according to the septal structure of the almost advolute whorls.

From the same horizon as *T. kirki flexicostatum* comes a much more coarsely costate large phragmocone which resembles *T. scissum* more than *T. kirki* (Pl. 72, fig. 7). However, the costae of the nucleus are convexly curved. Further material is needed to reveal if this is a variant of *T. kirki* or of *T. scissum,* which probably persists into the *E. howelli* Zone.

Comparison.—This subspecies is much more finely costate than *T. kirki s.s.,* especially on the inner whorls. The costation is similar as in *T. diffalense* (Gemmellaro, 1886), Bonarelli, 1893 [syn. *T. gemmallaroi* (Fucini), 1894] from the *"murchisonae"* Zone of the Central Apennine and the condensed Lower Bajocian (Aalenian) of Sicily. *"Cosmoceras Hollandae* var." (Buckman, 1883, pl. 1, fig. 2; 1892, pl. 48, figs. 4-7, the holotype by original designation, a synonym of *T. scissum*) is probably the microconch species corresponding to *T. diffalense* and is also said to originate in the *L. murchisonae* Zone (Sherborne, Dorset). Both species, the latter not yet named, differ in the narrower umbilicus and higher whorls (U=40-42%, H=35-38%, as compared to 48-50% and 28-32%, respectively) as well as in the strong external median ("ventral") groove and the more frilled septal suture. It is, nonetheless, of great interest that the morphological trend, in regard to the costation of *Tmetoceras* in Europe was similar to that in south Alaska.

This species resembles completely Prinz (1904, only pl. 16, fig. 3) hand-drawn figure of a *"T. scissum"* from Hungary. But this fauna needs photographic reproduction.

Measurements.—

	D mm.	W%	H%	U%	P
Holotype (body ch.)	49	—	28.5	48	26
pl. 29, fig. 9 (body ch.)	54	—	28	50	28
pl. 29, fig. 10 (phragm.)	32.5	23	32	49	18

Subgenus **TMETOCERAS (TMETOITES)** Westermann, subgen. nov.

Type species, *T. tenue* Westermann, sp. nov.

Diagnosis.—Small *Tmetoceras* with lappets; the microconch.

Tmetoceras (Tmetoites) tenue Westermann, sp. nov.

Pl. 73, figs. 1-9; Text-figs. 33, 35a

Holotype.—Pl. 73, figs. 1a-d; internal mold of 1½ ultimate whorls with peristome, somewhat deformed by lateral compression; nucleus as right impression. Coll. Imlay and Miller, 1948, Repository: U.S.N.M., 132051.

Locus typicus.—U.S.G.S. Mesozoic locality $48A_1$-109 (21254), at a tributary about 1 mile upstream Short Creek, Wide Bay, Alaska Peninsula.

Stratum typicum.—Top of *E. howelli* Zone ("Approximately 600′ below top of Kialagvik formation", according to U.S.G.S.). *T. tenue-flexicostatum* zonule.

Derivatio nominis.—*Tenuis-e*: thin, fine, slender; in accordance with the thin widely spaced costae.

Age.—Late Early Bajocian (late Aalenian) Upper (top) *E. howelli* Zone.

Diagnosis.—A species of *T. (Tmetoites)* with thin costae and wide flat interspaces usually bearing growth striae and often minute folds.

Material.—The holotype; two poorly preserved internal molds with body chambers, respectively, one well-preserved phragmocone, two good and one poor fragment, all somewhat deformed, 48A$_1$-109 (21254); (?) one almost complete specimen and (?) one well-preserved phragmocone fragment from A 8; (?) two poor impressions from L 154. All from *T. tenue-flexicostatum* zonule from the Upper *E. howelli* Zone, of Wide Bay. One complete but strongly depressed specimen with peristome from B 128, (Upper) *E. howelli* Zone of Puale Bay, Alaska Peninsula.

Description.—This species is apparently highly variable in size (12-30 mm. diameter), whorl shape and, to a less extend, in the costation, similar as *Tmetoceras scissum* (see Buckman, 1892, Frebold, 1951). However, the samples are not sufficient to exclude the possibility that two or three subspecies or even species are present.

The whorls are slightly involute to advolute and generally more or less strongly compressed-oval though this is partly due to postmortem compression; the two best preserved specimens from A 8, however, are almost circular in whorl section. The dimensional proportions do not appear to change significantly throughout at least the two ultimate whorls.

The juvenile whorls are smooth up to a diameter of 2.5-3.5 mm. Then appear densely spaced (12-14 halfwhorl) only moderately strong, straight or slightly sigmoid, usually rectiradiate simple costae, which carry distally a weak tubercle and fade in a short projection on the smooth gently rounded externside. The length of this densely costate juvenile stage apparently varies from a full whorl to near absence, usually ceasing at 4.5-6 mm. diameter. The ultimate one to almost two whorls have unusual widely spaced thin and relatively weak costae with interspaces several times as broad. The flat interspaces display fine parallel growth striae on well-preserved relatively large specimens, and more rarely also minute ridges which are apparently reduced costae. The costae are rectiradiate and usually slightly sigmoid or simply adaperturally convex, though this is often clearly evident only on the body chamber. As usual, the costae reach maximal height near their distal termination where a tubercle or spine is present which may point slightly backwards. There is often a fine rapidly fading forward projection beside the flattened or grooved smooth median zone, though the costae are abruptly truncated on the ultimate whorl of larger specimens. Near the aperture the costae may form a low continuous chevron over the externside.

The peristome is preserved on a small (B 112) and on a larger ($48A_1$-109) specimen. The last few costae become laterally increasingly convex indicating the gradual growth of lateral lappets which simply project from the last costa. The size of the lappets is 1×2.7 at the 12 mm. large specimen, but only 2×2 mm. at the specimen measuring 30 mm. in diameter. It is possible, however, that the latter (only the right lappet preserved) is broken off along the growth lines.

Septum and suture are exactly as in *Tmetoceras kirki.* The septal structure develops early from a planulate-like into a spirulate-like type with dominant cruciform axes. However, the elements are not homologous to Spiroceratidae because L ("1st lateral lobe"), reduced in the latter, appears to be here dominant.

Comparison.—The costae of *T. tenue* are much finer and more distantly spaced than in *T. alpinum.* The latter species is also distinguished by the rounded and totally smooth interspaces. *T.* (*Tmetoites*) *sp. nov.* A has much more densely spaced and projected costae.

Measurements.—

		D mm.	W%	H%	U%	P
Holotype	(aperture)	ca.30	—	ca.30	ca.40	15
Pl. 73, fig. 1	(phragm.)	ca.22	—	—	—	11
	"	ca.16.5	—	—	—	8-9
	"	11	—	—	—	8
Pl. 73, fig. 6	(phragm.)	15.5	—	33	45	12-13
	"	11	—	—	ca.43	11-12
	"	7.5	—	—	—	13
	"	4.8	—	—	—	13
Pl. 73, fig. 8	(body ch.)	ca.25	—	—	ca.46	15

Pl. 73, fig. 9	(body ch.)	ca.29	—	—	ca.50	15
	(phragm.)	ca.22	—	—	ca.45	12
	”	ca.15.5	—	—	—	12
Pl. 73, fig. 5	(body ch.)	ca.21	—	—	—	15
	(phragm.)	ca.12	ca.18.5	ca.25	—	8- 9
Pl. 73, fig. 7	(body ch.)	13.5	ca.25.5	ca.29.5	48	13-14
	(phragm.)	10.0	31	33	41	—
	”	7.0	33	36	40	13
(from A 8,	”	ca.15	30	33	—	ca.11-12
no fig.)	”	ca. 8-9	—	—	—	—
Pl. 66, fig. 2	(aperture)	ca.11	—	—	—	13-14

Tmetoceras (Tmetoites) cf. **T. alpinum** (Thalmann), 1924

Pl. 73, figs. 11a-d

1924. *Helicoceras alpinum* Thalmann (Berner Oberland), Mitt. Naturforsch. Ges. Bern. 1923, p. XXII, text-fig. on p. XXIII.

Material.—A single, laterally somewhat compressed, almost complete small specimen, phragmocone partly only as a right imprint, from A250 in the (Middle or) Upper *E. howelli* Zone of Wide Bay, Alaska Peninsula.

Holotype.—The species was based on a single fragmentary specimen 9.5 mm. in diameter, from the "Eisensandstein-Schichten des Pletsbaches bei Mürren (Berner Oberland)." The specimen is also somewhat distorted so that Thalmann believed that it was helicogyr, though not so strongly as in *"Helicoceras" teilleuxii* d'Orbigny with which it was thought to be most nearly related. The description mentioned further: the presence of distal tubercles on the slightly retrojected costae; the interspaces on the whorl sides are double as broad as the costae and totally smooth; a "relative" broad smooth "ventral" furrow; on the umbilical edge the costae bend backwards, slightly S-shaped; septal suture not preserved. The aperture is missing though the preserved ultimate halfwhorl almost certainly represents the almost complete body chamber, in agreement with the strongly increasing convexity of the last costae. According to the figure (×3) the costae are strong and the interspaces rounded, from at least 3 mm. diameter to the end of the preserved body chamber.

Description.—The whorls of the single specimen are subcircular except for the postmortem compressed parts, and probably advolute. Strong markedly adaperturally convex costae commence already at 2.5 mm. diameter. There are constantly about 12 costae per halfwhorl on the phragmocone and 14 on the halfwhorl body chamber. All interspaces are well rounded and smooth. The external part of the whorl is visible only on the body chamber. The costae are here adapically overturned, building almost a shingle-like structure, probably owing to the lateral postmortem compression of the high costae. Only the bullae-like tubercles and their short extension are projected. Owing to the compression the shape of the external interruption and groove cannot be accurately observed. The end of the body chamber on the preserved right side shows the strongly increasing convexity of the last few costae, indicating the gradual development of the lateral lappet, which is partly visible on the impression. The maximal diameter is only 14 mm.

Comparison.—This specimen almost exactly resembles the holotype, which is obviously distorted. This species is distinguished from *T. tenue* and *T. sp. nov.* A by the much coarser and earlier commencing costae. *T. alpinum* appears to be the "microconch" of *Tmetoceras (s.s.) kirki* found in beds of similar age.

Measurements.—

		D	W%	H%	U%	P
Holotype	(body ch.)	9.5	32(+)	30(+)	—	12-13
(acc. Thalmann + photo)	"	5	—	—	—	12
Pl. 72, fig. 11	(Aperture)	14	ca.21(+)	ca.32(—)	ca.50	14
	(phragm.)	5	ca.38	36	—	11-12

Tmetoceras (Tmetoites) sp. nov. A Pl. 73, figs. 10a-d

1903. *Tmetoceras* aff. *Gemmellaroi* Fucini, Burckhardt (Andes), Palaeont., 50. p. 21, pl. 2, figs. 4, 5.

Material.—A single small well-preserved complete specimen with aperture, from A 11, *T. tenue-flexicostatum* zonule at top of the *E. howelli* Zone, Wide Bay, Alaska Peninsula. Repository: U.W., 16657.

Description.—The whorls are advolute and strongly compressed oval at least from 3 mm. diameter up to the aperture at 16 mm. The juvenile whorls are smooth; the unusually dense and thin costation develops clearly at 4 mm. diameter. There are 16-17 straight and only slightly prorsiradiate costae per halfwhorl which become somewhat sigmoid on the ultimate three-fourths whorl and laterally markedly convex at the end of the exceptionally short body chamber (just over one-fourth whorl). The costae are distally moderately projected on most of the ultimate whorl and fine compressed nodes or spines are present. The moderately deep external furrow of the late phragmocone becomes obliterated on the body chamber where an extremely thin extension of the costae finally may build a chevron-like crossing of the highly rounded "venter."

Comparison.—The Alaskan specimen appears identical with Burckhardt's "*Tmetoceras* aff. *Gemmellaroi*" (see syn. list) from Barda Blanca, Rio Grande area, in the Andes. The single specimen came from the upper part of beds with *Meleagrinella substriata* which at Espinazito directly underlie the "*Sonninia* beds" and yield *Tmetoceras* cf. *scissum* and *Graphoceras* cf. *concavum*.

This unnamed new species is much more densely costate and probably also more compressed than *T. alpinum* (Thalmann) and *T. tenue*. It appears to be the "microconch" to *T. (Tmetoceras) kirki flexicostatum* with which it was found in the same bed.

Measurements.—

	D mm.	W%	H%	U%	P
(Aperture)	16	27	31	49.5	17
(phragm.)	12	30	35	49	16
"	8	—	—	—	ca.16

Suborder PHYLLOCERATINA Arkell, 1950

Superfamily **PHYLLOCERATACEAE** Zittel, 1884

Family **PHYLLOCERATIDAE** Zittel, 1884

Subfamily **PHYLLOCERATINAE** Zittel, 1884

Genus **PARTSCHICERAS** Fucini, 1923

Type species, *P. monestieri* Breistroffer, 1947.

Partschiceras cf. P. gardanum (Vacek), 1886

Pl. 74, figs. 1-3, Pl. 76

Material.—Three well-preserved internal molds of incomplete phragmocones with test remains: two from L 543, slightly laterally depressed by deformation; one from A 250 uncompressed; one (?) poorly preserved fragment from L 285; mostly from the Upper *E. howelli* Zone, Wide Bay. (See Appendix)

Description.—The phragmocone is extremely involute (convolute) and its whorl section compressed ellipsoidal with slightly flattened sides and a narrow rounded and partly "overhanging" umbilical wall. The whorl section of the nucleus, as observed in the polished section of the specimen from A 250, is circular at a diameter of 6 mm. and subsequently becomes gradually compressed until it is just 1½ times as high than broad at the end of the preserved phragmocone (about 60 mm. diameter).

Constrictions are absent and the internal mold is smooth. Fine somewhat prorsiradiate lirae distally developing into blunt fine radial folds are present superficially.

The septal suture displays three large "lateral saddles" (not preserved on umbilical slope) all of which are slender and typically diphyllic. (See Appendix)

Comparison.—The specimens resemble *Partschiceras gardanum* Vacek as figured from the Lower Bajocian of Cape St. Vigilio in the southern Alps (Vacek, 1886, p. 70, pl. 6, figs. —3). The alpine form may differ slightly in somewhat more compressed whorls and stronger folds.

Genus **HOLCOPHYLLOCERAS** Spath, 1927

Type species, *Am. zignodianum* d'Orb., 1848.

Holcophylloceras cf. **H. ultramontanum** (Zittel), 1869 Pl. 74, figs. 4-7

Material.—Three complete or almost complete internal molds: two from A 8 and one from A 10, more or less strongly deformed, some test remains; one undeformed fragment of a body chamber from L 543. All from the Upper *E. howelli* Zone of Wide Bay.

Description.—The phragmocone is poorly preserved. The body chamber is involute though originally less apparent, and its whorl section is somewhat rectangular with a rounded steep rather narrow umbilical wall. The two small specimens from A8, 33 mm. and 42 mm. in diameter, have body chambers about two-thirds whorl in length and their apertural structure possibly suggests that they were adult. The larger specimen from A 10 (54 mm. diameter) with halfwhorl body chamber and the fragment from A 513 suggest a final diameter of about 60 mm.

The body chambers display deep falcate constrictions which are laterally strongly bent forward and distally strikingly projected. They cross the externside more shallowly in narrowly curved to angular chevron-fashion enclosing an angle of 80-100°. Between the constrictions are falcoid lirae which laterally and distally are generally more gently curved than the constrictions and which finally become weak folds on the outer part of the large specimens.

The preserved lateral parts of the septal suture on the specimen from A 10 shows simple diphyllic saddles.

Comparison.—The specimens agree well with *H. ultramontanum* (Zittel), reported from the Lower Bajocian of the Balkan Peninsula, the Alps, the Central Apennines, and recently also from the Lower Bajocian of Japan (see Vacek, 1886, pp. 65-66, pl. 5, figs. 15-20; Sato 1957, p. 342). The (Middle ?) and Upper Jurassic *H. mediterraneum* (Neumayr) [= ? *H. zignodianum* d'Orb.] is distinguished in the straight or only slightly projected constrictions and lirae as well as in the ovate whorl section. *H. torulosum* (Tornquist) from the Middle Bajocian of Espanazito, Argentina, is a near relative of *H. mediterraneum*.

Genus **PHYLLOCERAS** Suess, 1865

Phylloceras ? sp.

From locality A 86 comes a single large poorly preserved fragment belonging to a phragmocone of approximately 120 mm. diameter. The umbilical slope is missing. The surface is smooth except for densely spaced (ca. 5 per cm.) radial lirae which cross the externside straight and in undiminished strength.

APPENDIX TO SYSTEMATIC DESCRIPTION

After this monograph was finished and in the hands of the editor, three specimens from the same sequence were identified by the author in the collections of the California Academy of Sciences (C.A.S.), San Francisco, California, which have important taxonomical bearing on, or supplement, the aforementioned Wide Bay fauna from the Kialagvik formation. These specimens are (1) *Harpoceras* (*Harpoceras?*) sp. indet. from the *E. howelli* zonule, believed to be derived from the Toarcian, (2) *Erycites imlayi, sp. nov,* from the *E. howelli* zonule which closely resembles the holotype of the apparently varying species, and (3) *Partschiceras gardanum* (Vacek), subsp.?, which now permits specific identification of the Alaskan *Partschiceras*. The author wishes to express thanks to Dr. L. G. Hertlein for the loan of the specimens.

Family **HILDOCERATIDAE** Hyatt

Subfamily **HARPOCERATINAE** Neumayr

Genus **HARPOCERAS** Waagen

The type species by subsequent designation is *Am. falcifer* J. Sowerby from the *H. falzifer* Zone. The genus is generally believed to be restricted to the Lower Toarcian (Arkell, 1957, p. L 256).

Harpoceras (Harpoceras?) sp. indet. Pl. 75, figs. 1a, b

1929. *Grammoceras* cf. *saemanni* (Dumortier), Frebold (Spitzbergen), p. 263, pl. 2, figs. 6, 7.
1960. *Grammoceras?* sp. indet., Frebold (Canadian Arctic), p. 23, pl. XII, figs. 5, 6, 7.

Material.—A single phragmocone, parts of the "venter" missing and surface partly corroded; in contrast to the rich co-occuring fauna, the specimen gives the striking impression of reworking. The specimen comes from the California Academy of Sciences, Loc. 29016: the "Type locality of the Jurassic Kialagvik formation; dark greenish-grey medium-grained sand and sandy shale from the west shore of Wide Bay just south of the mouth of Pass Creek . . . [associated with] ammonites, gastropods, bivalves and fossil wood. Field No. 81". This is almost certainly the *E. howelli* zonule, *E. howelli* Zone.

Description.—The whorl section is at first compressed suboval with gently sloping inner flanks, but at about 12 mm. diameter becomes subrectangular. Thus, 1½ ultimate whorls are about twice as high as broad, the flanks are flat and well separated from the almost vertical umbilical wall by a sharp umbilical margin which, on the ultimate halfwhorl, develops into a raised rim. The "venter", visible only on the ultimate whorl, is somewhat flattened and has a narrow moderately high solid keel with semi-circular section on the internal mold. The umbilicus is of moderate similar width throughout the ultimate three whorls and later typically "stepped".

The costation is typically falcate and strong on all three ultimate whorls with the number per halfwhorl increasing from 12 to 18. The costae are regular and never fasciculate. They commence at some distance from the immature umbilical seam and later directly at the umbilical margin, project forward onto the middle of the flank where they turn sharply backward, continue up to the shoulders and bend here strongly forward, terminating at the smooth keel zone under an angle of approximately 45 degrees. The costae reach their greatest strength on the shoulders. They appear densely spaced on the inner whorls of the phragmocone.

The septal suture is simple and nonsuspensive with straight saddle boundary.

Remarks.—This specimen agrees in all observed details with the forms described by Frebold from condensed middle and upper Toarcian beds of Spitzbergen and from the upper Toarcian of Cornwall and Ellesmere Islands, Canadian Arctic (see synonymy). Frebold originally believed the Spitzbergen forms to be closely affiliated with *Grammoceras saemanni* (Dum.) but later noticed that they differ from *Grammoceras* in the more sharply bent and less numerous costae and the narrower umbilicus. Therefore, in the author's opinion, these forms are much closer to typical *Harpoceras* and, indeed, strongly reminiscent of *H. falcifer*.

On Ellesmere Island, this species occurs together with *Pseudolioceras* ex gr. *P. compactile* (Simpson) and *Catacoeloceras polare* (Frebold), a faunule characteristic of the uppermost Toarcian of east Greenland and Prince Patrick Island, and superjacent to beds with *Dactylioceras commune* (Sow.) which can be correlated with the *H. falcifer* Zone. The beds with *Harpoceras* described herein can, therefore, be dated as probably lower *L. jurense* Zone, but the upper *H. falcifer* Zone also has to be considered.

From North Alaska, a similar succession of dactylioceratid and

Pseudolioceras ex gr. *compactile* faunules has been described (Imlay, 1955), but no harpoceratids were reported. Significantly, the only evidence of Toarcian strata in south Alaska is from the Puale Bay (and Alinchak Bay) just east of Wide Bay (Imlay, 1952).

The Wide Bay specimen described above from the exceptionally fossilferous *E. howelli* zonule is believed to have been derived from reworked Toarcian beds of the vicinity.

Acknowledgment is made to Dr. H. Rieber, Zürich, the authority on Graphoceratidae, who convinced the author that this specimen is not a *Ludwigia s.l.* (as originally suspected).

Measurements (in mm.).—

	D	H%	W%	U%
(phragm.)	50	20	12	ca.14

Family **HAMMATOCERATIDAE** Buckman

Subfamily **HAMMATOCERATINAE** Buckman

Genus **ERYCITES** Gemellaro

Erycites imlayi Westermann, sp. nov. Pl. 65, figs. 1, 2; Pl. 75, figs. 2a-c

A complete specimen with largely preserved aperture and test comes from the *E. howelli* zonule, *E. howelli* Zone, of the same locality as the *Harpoceras* described above (C. A. S. Loc. 29016).

This specimen agrees in detail with the holotype described in the main part of this monograph. The whorl section is depressed with narrowly rounded flanks at about three-sevenths whorl height. The specimen deviates slightly in the somewhat narrower umbilicus. The septal suture shows the same reduction of the "ventral" elements, which is diagnostic for *Erycites,* and the same weak costae interruption with obsolescent keel; the test of the end of the phragmocone displays increasingly flattening costae which are subcontinuous, comprising an obtuse angle, but on the internal mold of the body chamber a faint ridge rises from the smooth "ventral" band.

The test is unusually thick and reaches 1.5 mm. already on the inner flanks of the phragmocone and 3.2 mm. at the sides of the aperture.

Of special interest is a spiral grooving observed on the internal mold of the body chamber. It is best developed on the right side where a broad groove adjacent to the umbilical seam is accompanied by several lirate fine undulations on the inner flank. Although best seen along the middle third of three-fourths whorl body chamber, this structure appears to be present on its whole length. The internal mold of the phragmocone is unknown.

Measurements (in mm.).—

	D	H%	B%	U%	P	S	W/H
(aperture, test)	87	38	31	40	13	31	1.2
(phragm., test)	ca.52	ca.59	ca.37	ca.31	13	ca.36	1.4
(int. mold)	ca.56	ca.46	ca.34	ca.40	13	ca.36	1.35

Family **PHYLLOCERATIDAE** Zittel

Subfamily **PHYLLOCERATINAE** Zittel

Genus **PARTSCHICERAS** Fucini

Partschiceras gardanum (Vacek), 1886, subsp?
Pl. 74, figs. 1, 2, 3; Pl. 76, figs. a-d

A single large specimen came from California Academy of Sciences, Locality No. 29017, a "cliff exposure on the west shore of the south end of Wide Bay, inside hook made by long sand spit: Kialagvik formation (Field No. 99)". This is somewhere between the eastern termination of the Moose Creek-Mt. Kathleen section and shell locality A 86, where the sea cliff exposes the middle and lower Upper *E. howelli* Zone, *i.e.* the *T. teres-profundus* to *Eudmetoceras* beds. The specimen is fully septate at 92 mm. diameter, uncompressed with most of the test preserved; the septal suture, umbilicus and some inner whorls are well exposed.

This form is identical with the fragmentary smaller specimens described in the main part of this monograph and can, with some confidence, be identified with *Partschiceras gardanum* (Vacek) from the Alps and western Tethys. However, like the other Alaskan specimen, this phragmocone is slightly distinguished in the more inflated whorls, *i.e.* the larger relative whorl-width, and probably also in the ovoid rather than ellipsoidal whorl section. The Alaskan form may, therefore, be a geographical (? and chronological) subspecies of the Tethyan species.

This specimen totally resembles the type specimen in the superficial costation which is slightly prorsocostate and somewhat irregular. The specimen shows costae irregularity mainly at a diameter of 67 mm. which may be regarded as owing to "segmental growth". The septal suture has typically diphyllic saddles and agrees well with Vacek's figure 11a.

Measurements (in mm.).—

	Dmm.	H%	W%	U%
(phragm.)	92	57	38	4.5
"	51	65	41	5
"	ca.30	ca.62	ca.42	ca.5

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RUSSIAN SUMMARY

Резюме: Кялагвикская формация представляет собой нижние 300-600 м. средней и верхней Юрской кластической серии, обнаженной в антиклинали Широкого залива уложена литофациевыми изменениями и нарушениями. Границу с вышележащей шеликовской формацией теперь относят к среднему Байоциану: она имеет сильно выраженный гетерохронный характер. Базальтные 100 м. содержат наиболее раний Tmetoceras scissum (Ben.). найденый в байоцианевом периоде. Зона Howelli, nov. толщиной около 300 м. содержит богатые и хорошо сохранившиеся аммонитовые накопления с характерным новым родом гамматокератид Erycitoides и новым подродом E. (Kialagvikes), которые вместе состоит из двух старых и пяти новых видов: новыми типами так-же являются виды Erycites, Abbasites, Tmetoceras и так-же подряд T. (Tmetoites) . Делается подразделение следующие зонулы: Howelli, teres-profundus, Eudmetoceras, и tenueflexicostatum Эта фаунаэндемическая для Аляски и северного Юкона. Нахождение здесь же Европейских и Аргентинских Eudmetoceras (Euaptetoceras) amplectens (Buck.), E. eudmetum jaworskii nov. и Abbasites указывают на то что зона Howelli относится к позднему раннему Байоцианскому позднему Аалениан периоду зони Howelli.

Явные половые димофорные формы гамматокератинов и тметокератинов которые до этих пор не были известны подвергаются подразделению на подроды. Дается описание первого Hammatoceratidae aptychus, Praestriaptychus antiquus sp. nov.

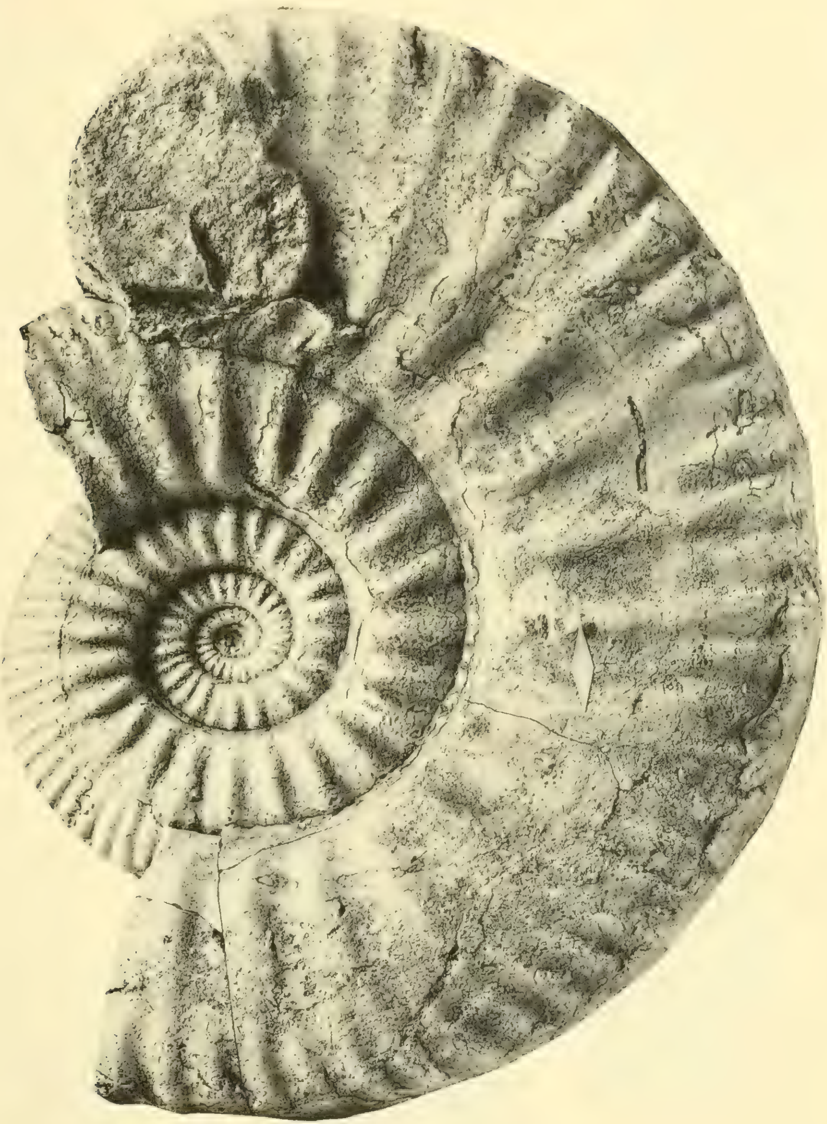
PLATES

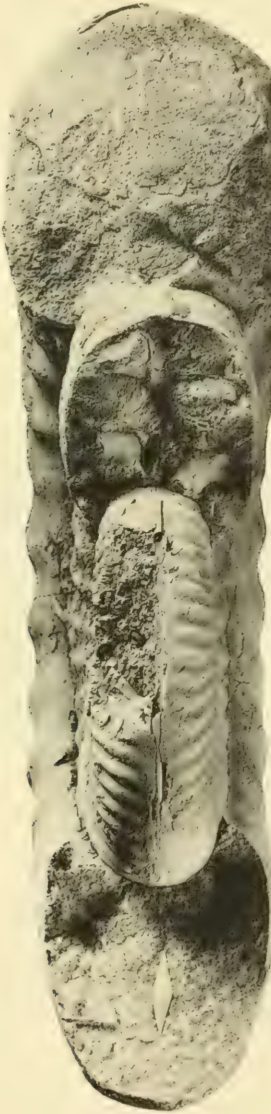
Explanation of Plate 44

Natural size if not otherwise indicated.

Figure	Page
Erycitoides howelli (White)	360

Lectotype. Internal mold with some test remains at umbilical seam and apertural constriction. Kialagvik formation, almost certainly *E. howelli* zonule, Wide Bay (label marked "Wrangel Bay"); see Plate 64, figs. 1a, b. U.S.N.M. 132022.





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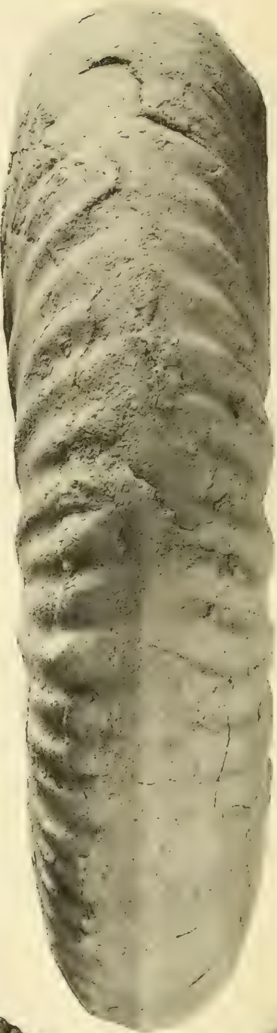

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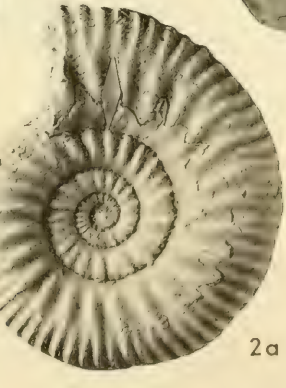

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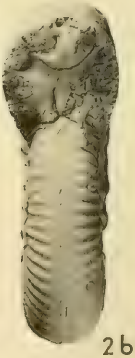


2b

Explanation of Plate 45

Natural size if not otherwise indicated

Figure		Page
1-2b.	**Erycitoides howelli** (White)	360

Kialagvik formation, almost certainly from *E. howelli* zonule, Wide Bay (labels marked "Wrangel Bay").

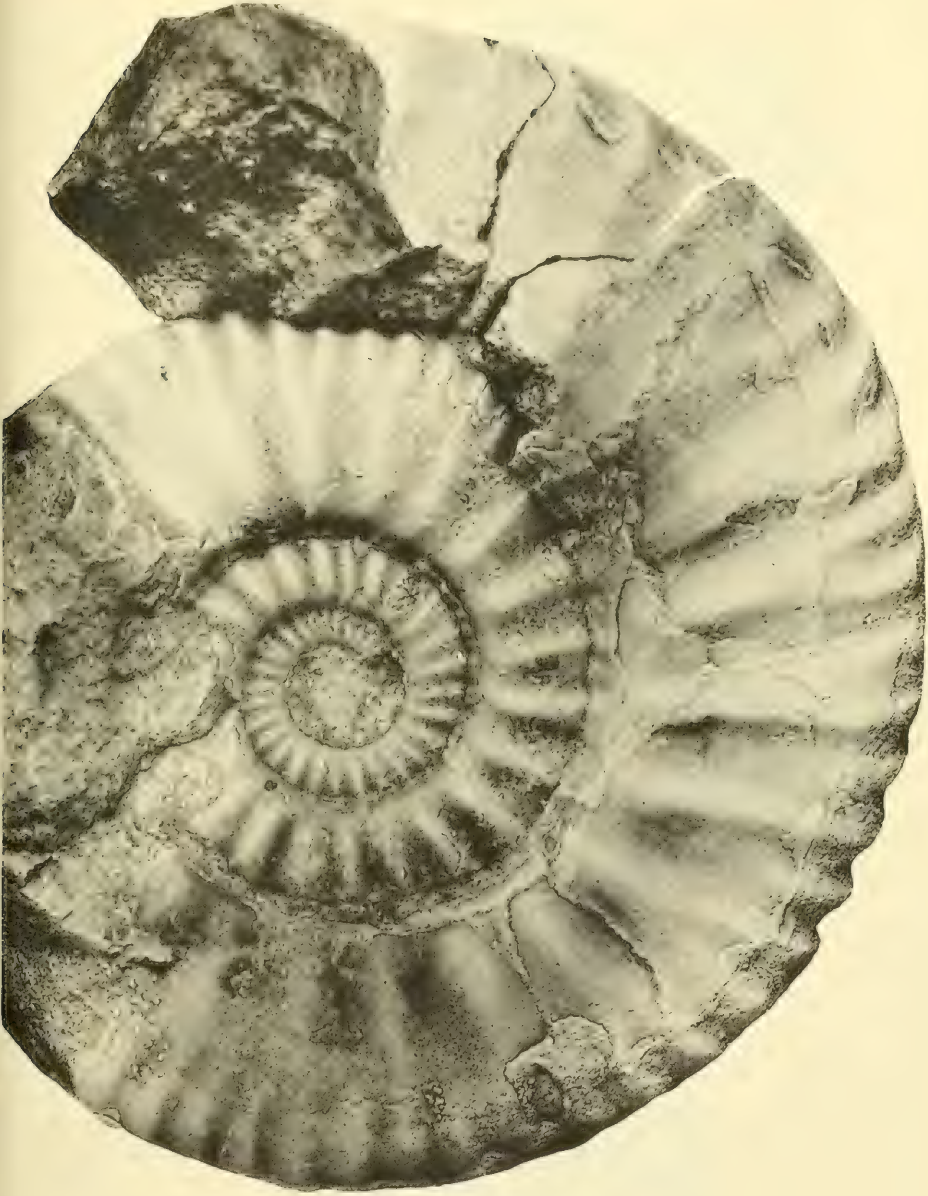
1 a,b. Lectotype, external views (see Pl. 44). 2 a,b. Paratype ("cotype" White's); inner whorls as internal mold with test remains; primaries coarser than on lectotype and partly tuberculous. U.S.N.M. 132032.

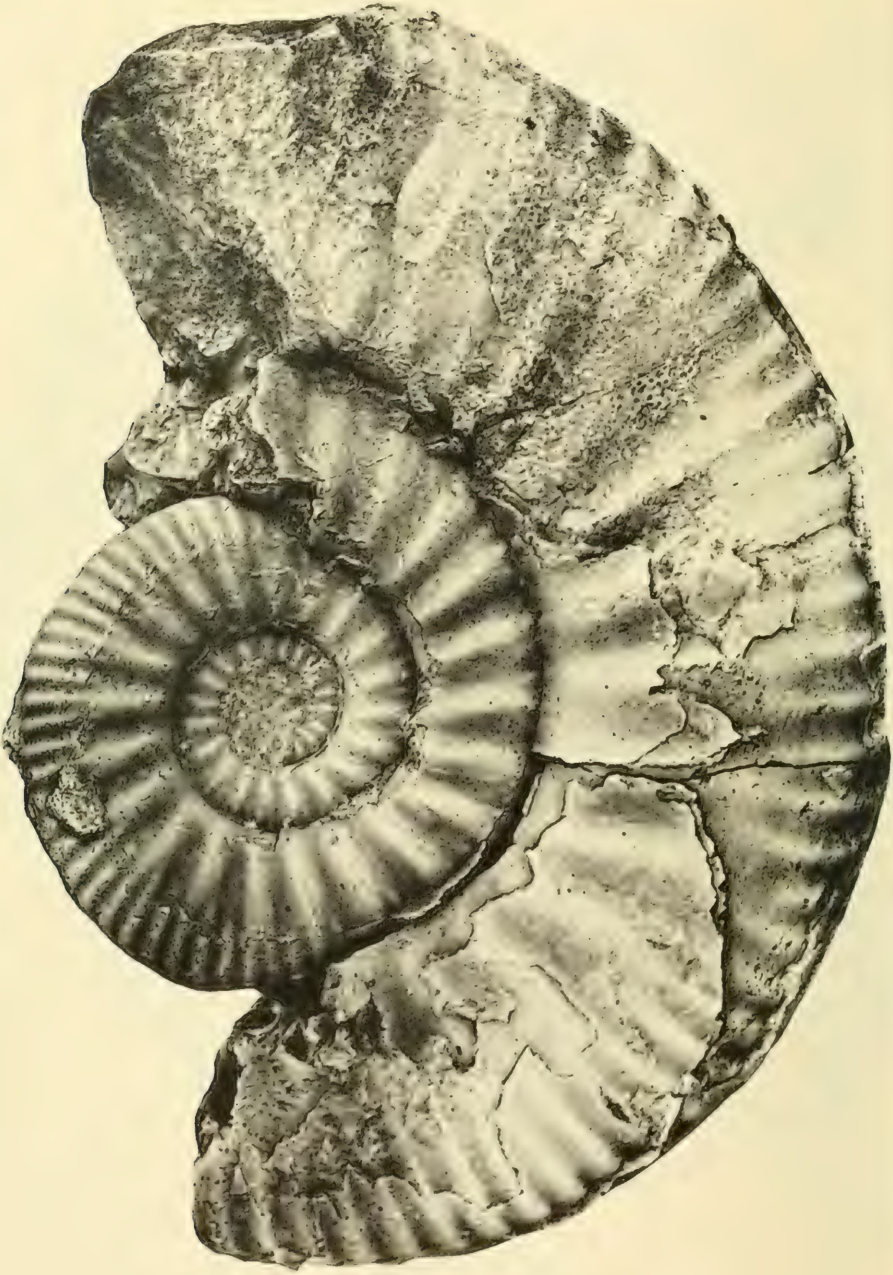
Explanation of Plate 46

Natural size if not otherwise indicated.

Figure	Page
Erycitoides howelli (White)	360

Internal moll of average specimen, with peristome. Kialagvik formation, Loc. A 444 in *E. howelli* zonule, Wide Bay. U.W. 16566.





Explanation of Plate 47

Natural size if not otherwise indicated.

Figure	Page
Erycitoides howelli (White)	360

Internal mold with test remains of phragmocone and 1/3 body whorl; primaries thickened, secondaries weakly subfasciculate on nucleus, fine on body chamber. Kialagvik formation, Loc. A 446 in *E. howelli* zonule, Wide Bay. U.W. 16567.

Explanation of Plate 48

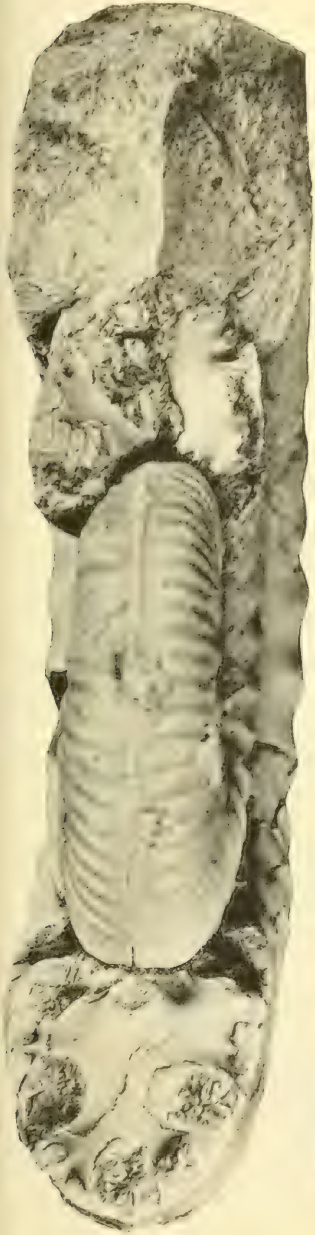
Natural size if not otherwise indicated.

Figure Page

1-4b. **Erycitoides howelli** (White) 360

Kialagvik formation, *E. howelli* zonule, Wide Bay.

1. External view, whorl sections and septa of specimen figured on Plate 47. 2. External view of finely costate inner whorls, septa and whorl sections of internal mold. Loc. A 446. U.W. 16568. 3. As before, totally septate, but test preserved on upper part of figure exhibiting prominent superficial keel. Loc. A 444. U.W. 16569. 4 a,b. Lateral, external, and septal view on fully septate fragment with subfasciculate fine costation. Loc. A444. U.W. 16570.



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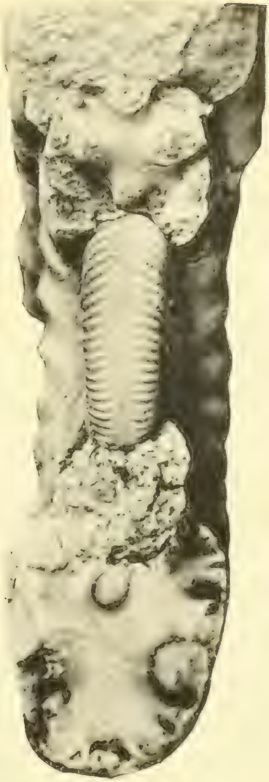

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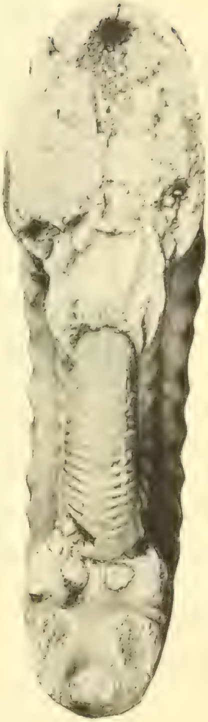

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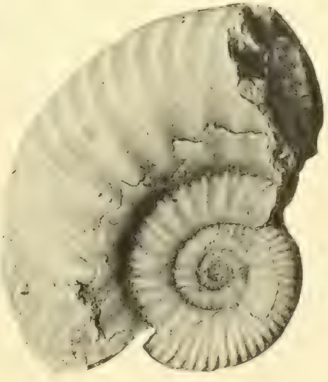

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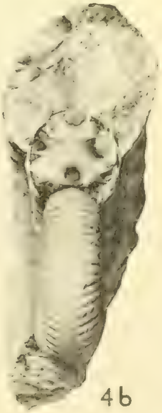

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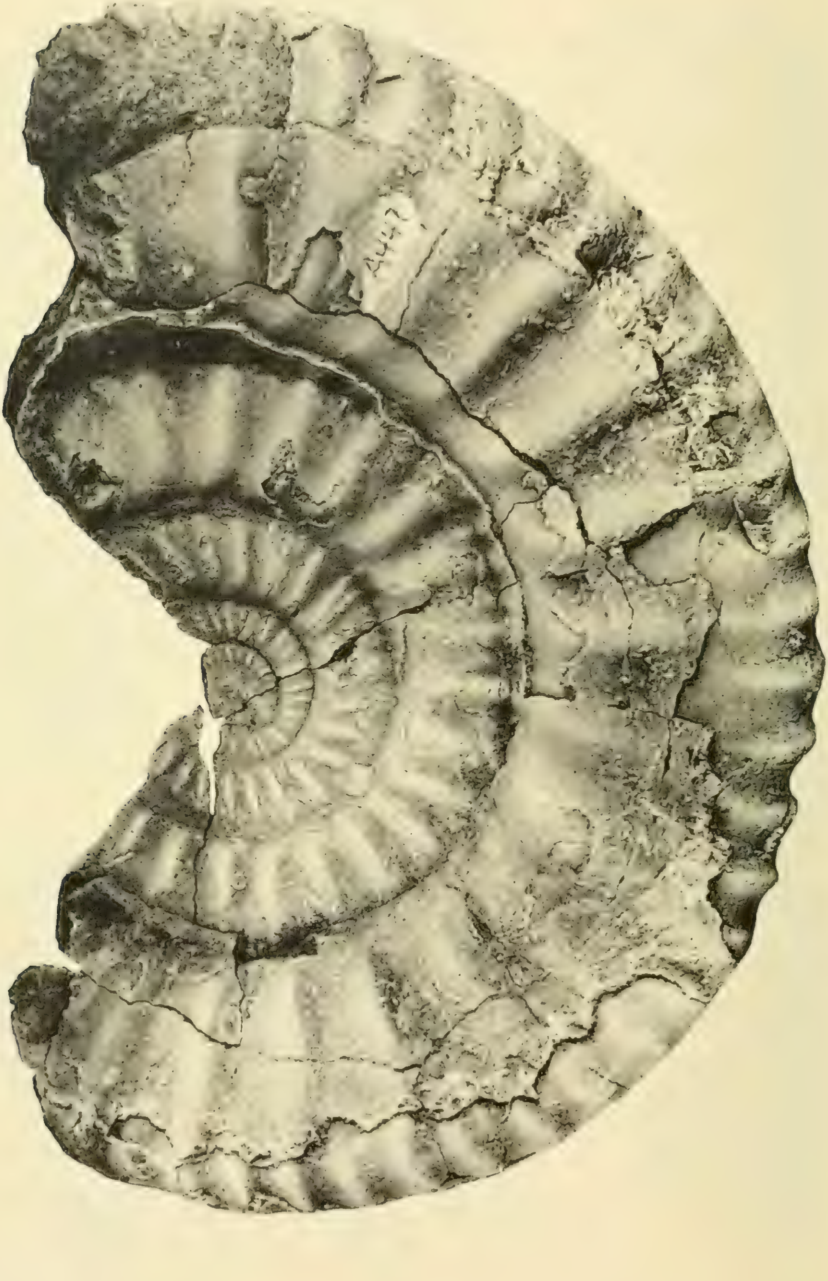


Explanation of Plate 49

Natural size if not otherwise indicated.

Figure	Page
Erycitoides howelli (White)	360

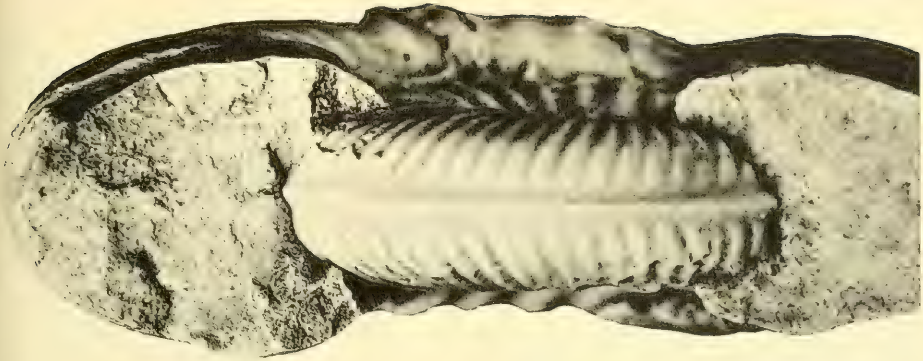
Specimen with 3/5 whorl preserved body chamber, with test; evolute, compressed variant with long primaries. Kialagvik formation, Loc. A 447 in *E. howelli* zonule, Wide Bay. U.W. 16571.

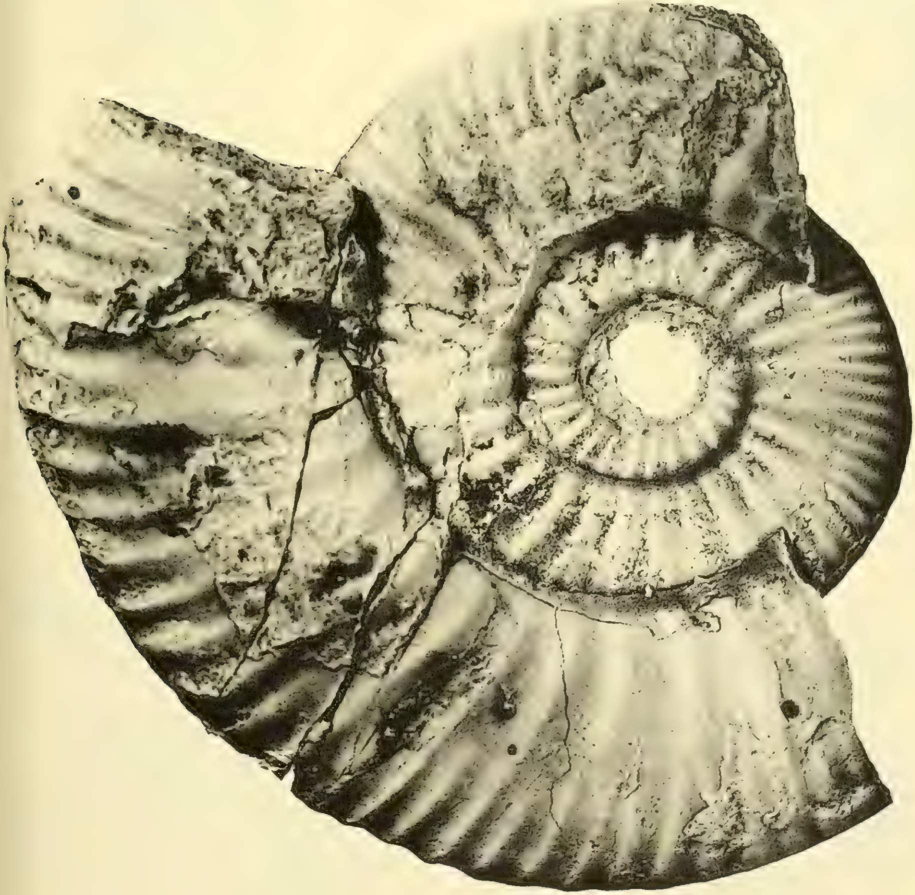
Explanation of Plate 50

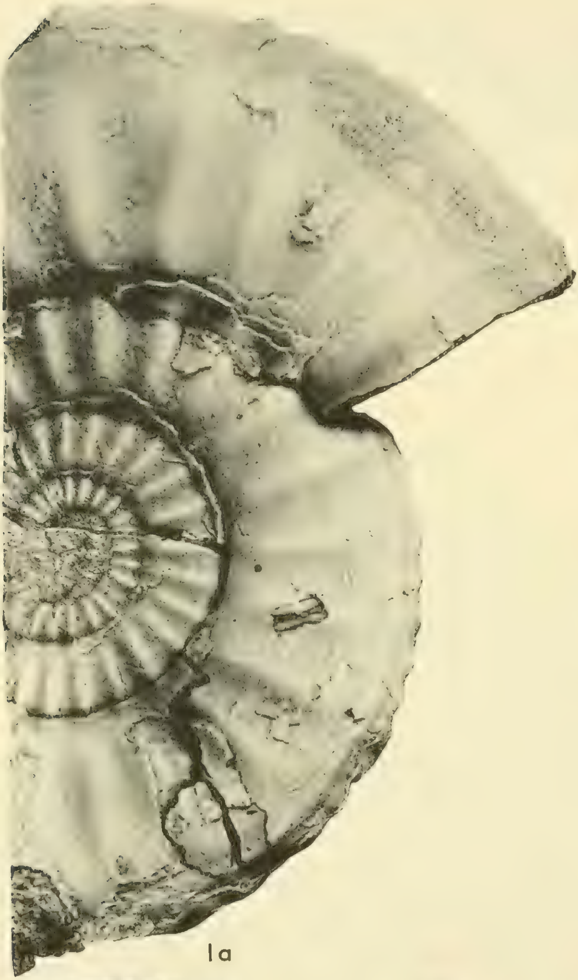
Natural size if not otherwise indicated.

Figure	Page
Erycitoides howelli (White)	360

Internal mold with incomplete aperture, test remains on prominently keeled penultimate whorl and apertural constriction. Whorl section, costation, and keel resembling *E. profundus*. Kialagvik formation, Loc. L 285 in the *E. howelli* zonule, Wide Bay. U.W. 16572.



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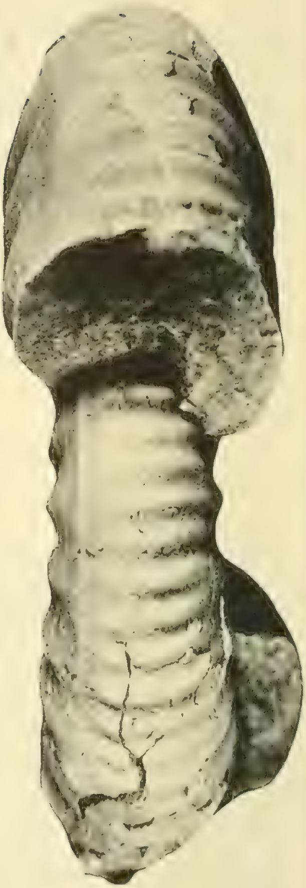
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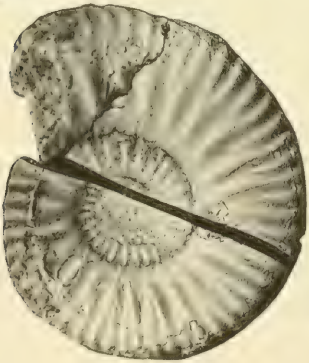
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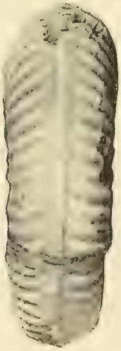
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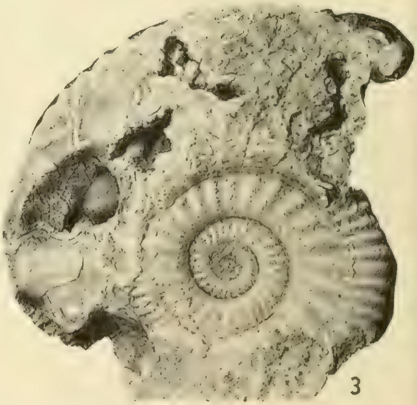
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Explanation of Plate 51

Natural size if not otherwise indicated.

Figure		Page
1-3.	**Erycitoides howelli** (White)	360

Kialagvik formation, *E. howelli* zonule, Wide Bay.

1 a,b. Pathological specimen with costae type "stadium abruptum"; keel displaced, right secondaries missing; internal mold with 1/4 whorl body chamber. Loc. L 258. U.W. 16573. 2 a,b. Inner whorls, largely with test, of a typical specimen; keel prominent, dissected. Loc. L 258. U.W. 16574. 3. Inner whorls, internal mold, with fine subfasciculate costae on the nucleus; strongly "retracted" umbilical lobe faintly visible. Loc. A 444. U.W. 16575.

Explanation of Plate 52

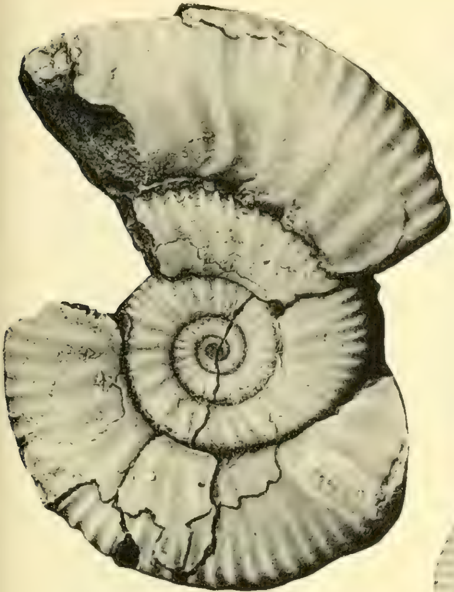
Natural size if not otherwise indicated.

Figure Page

1-6. **Erycitoides howelli** (White) 360

Kialagvik formation, *E. howelli* zonule, Wide Bay.

1. Small, but apparently adult specimen with 3/4 whorl body chamber and partially preserved aperture; last two sutures somewhat approximated; costation fine and partly subfasciculate. Loc. A 449. U.W. 16576. 2. Inner whorls of compressed variant with average costation; internal mold, suture partly visible. Loc. L 285. U.W. 16577. 3 a,b. Inner whorls of round-whorled specimen with fine costation which is subfasciculate on the nucleus, internal mold with suture. Loc. A 444. U.W. 16578. 4. Inner whorls fragment of compressed specimen with typical costation, partly subfasciculate on nucleus. Loc. L 285. U.W. 16579. 5. Adolescent specimen with 1 whorl body chamber (1/4 whorl preserved on impression only); last sutures not approximated, strongly "retracted"; phragmocone with test, body chamber largely as internal mold; strong and distantly spaced primaries carry lateral spines on inner whorls, the secondaries are restricted to the outer flanks; the whorls are subcircular and scarcely involute. Loc. L 285. U.W. 16580. 6. Probably not fully grown specimen with approximately 1/2 body chamber; test largely preserved on inner whorls exhibiting moderately strong primaries with lateral tubercles weaker than in Figure 5. Loc. F 23 (19757). U.S.N.M. 132024.



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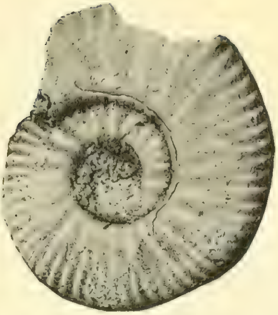

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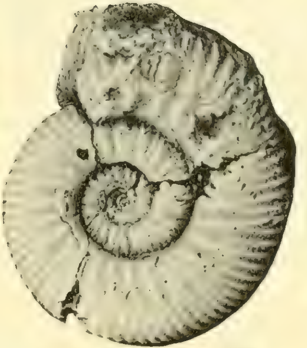

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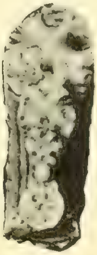

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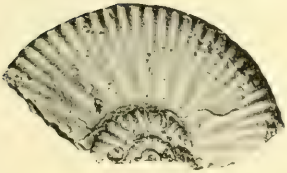

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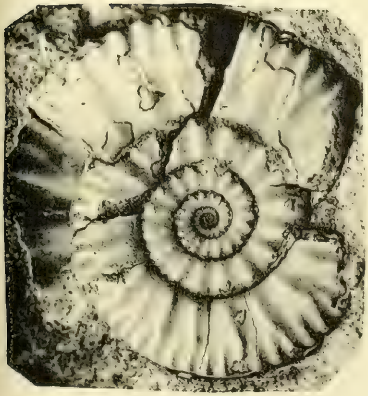

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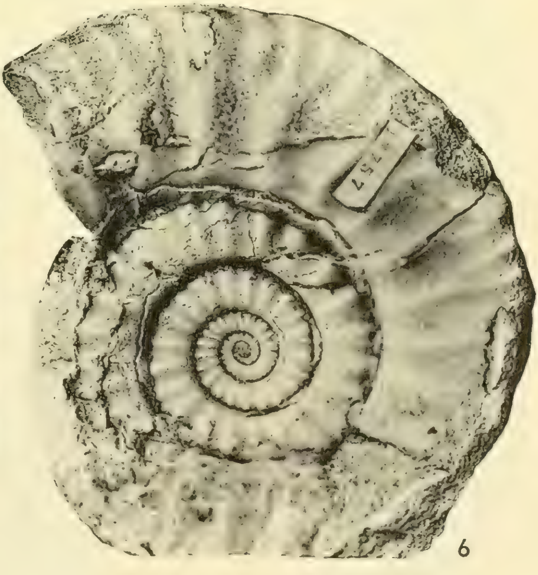

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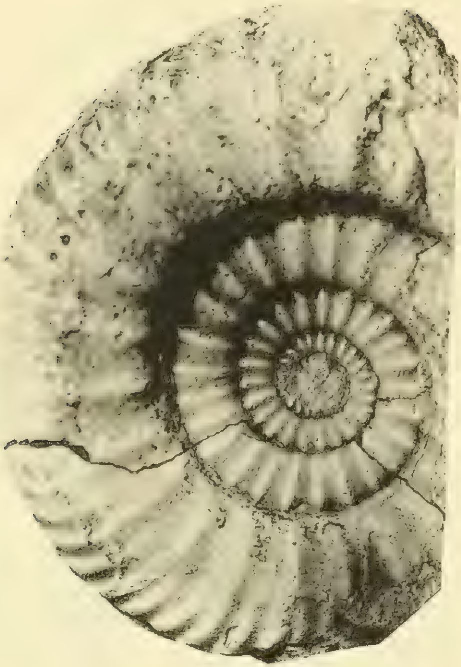

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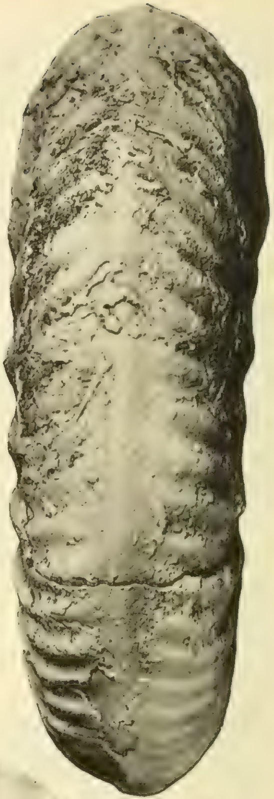

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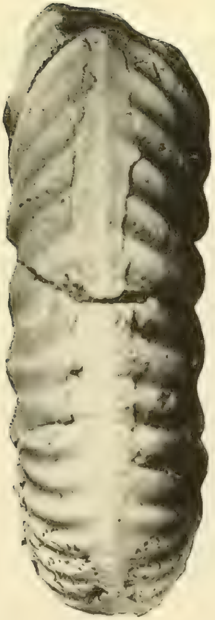

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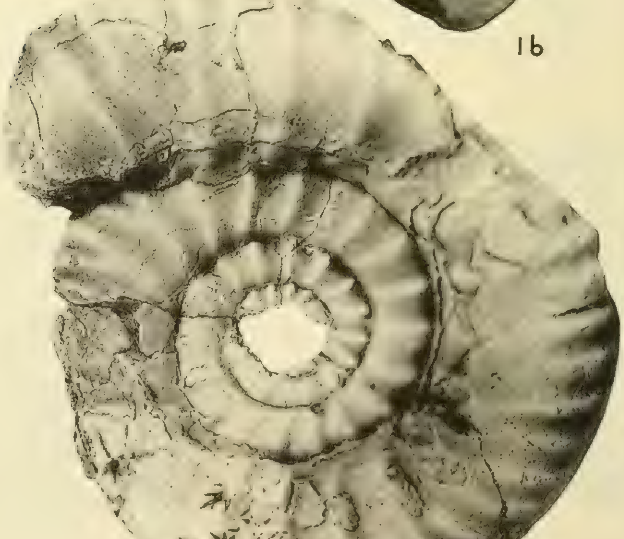

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Explanation of Plate 53

Natural size if not otherwise indicated.

Figure		Page
1-2b.	**Erycitoides howelli** (White)	360

Kialagvik formation, *E. howelli* zonule, Wide Bay.

1 a,b. Fully septate internal mold of spinose and coarsely costate variant with somewhat triangular whorl section and prominent keel. 1a×0.8. Loc. L 285. U.W. 16581. 2 a,b. Not fully grown specimen (sutures not approximated) of same variation, largely with test, mainly phragmocone deformed by lateral compression; 3/5 body chamber. Probably same locality. U.W. 16582.

Explanation of Plate 54

Natural size if not otherwise indicated.

Figure Page

1-2. **Erycitoides howelli** (White) 360

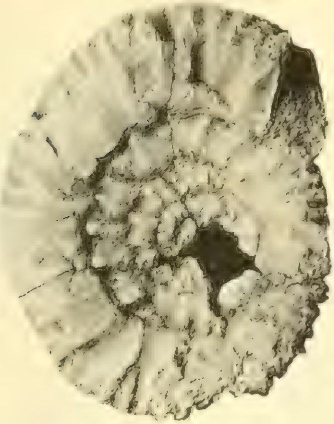
1 a,b. Adolescent specimen of the spinose, evolute variation with 3/5 whorl body chamber, partly with test, deformed. Kialagvik formation, *E. howelli* zonule (Shell coll.), Wide Bay. U.W. 16583. 2. Inner whorls of spinose variant. Kialagvik formation, Loc. A 454 in *E. teres-profundus* zonule, Wide Bay. U.W. 16584.

3-4. **Erycitoides** sp. nov.?, aff. **E. howelli** (White) 377

3 a,b. Internal mold with few test remains; ½whorl body chamber. Kialagvik formation, Loc. L 1067 in *E. teres-profundus* zonule, Wide Bay, U.W. 16585. 4 a,b. Small (adolescent ?) specimen with more than ¾ whorl body chamber, with test. Kialagvik formation, Loc. L 285 in *E. howelli* zonule, Wide Bay. U.W. 16586.

5-6. **Erycitoides paucispinosus** Westermann, sp. nov. 385

5 a,b. Holotype; internal mold with over 1 whorl body chamber (partly missing), parts of aperture probably preserved. Kialagvik formation, Loc. A 454 in *E. teres-profundus* zonule, Wide Bay. U.W. 16587. 6 a,b. Internal mold with some test and ½ whorl body chamber; right side largely missing. Kialagvik formation, Loc. L 1067 in *E. teres-profundus* zonule, Wide Bay. U.W. 16588.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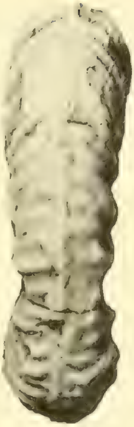
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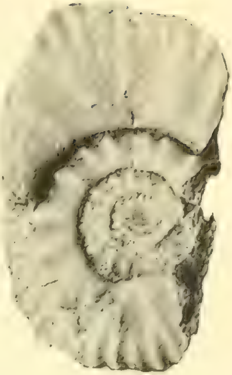
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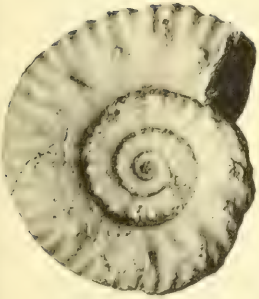
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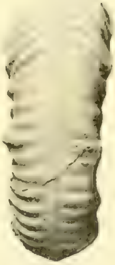
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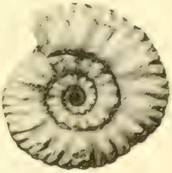
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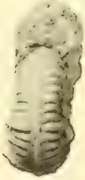
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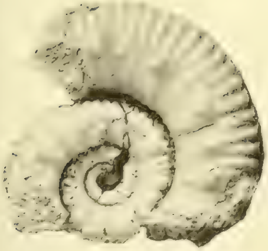
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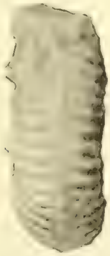
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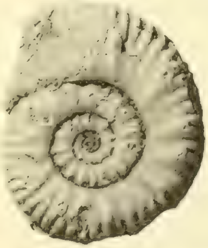
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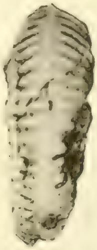
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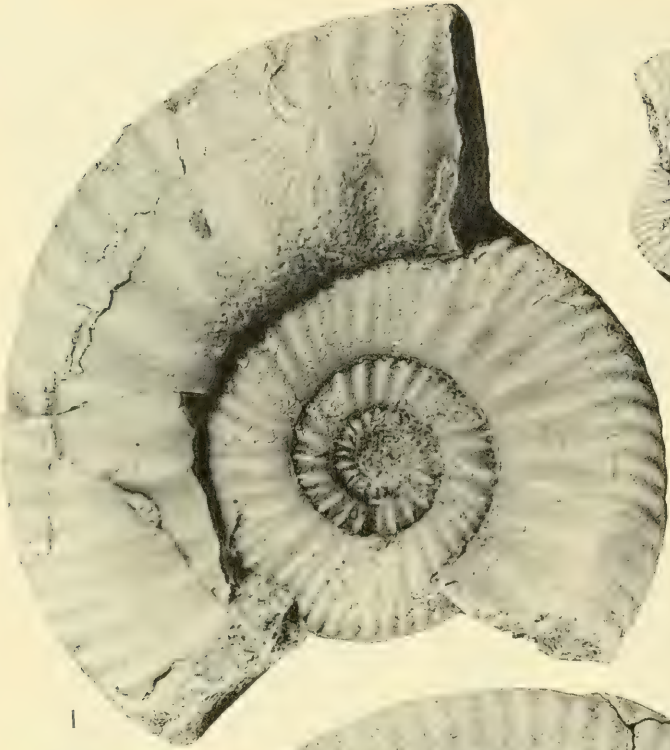
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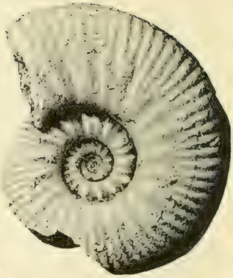
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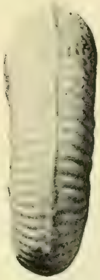
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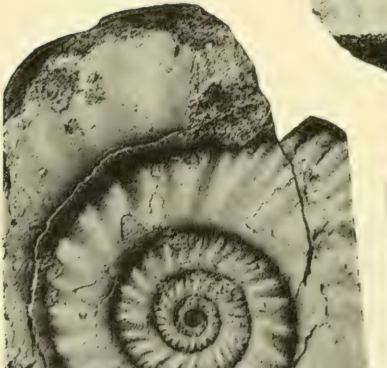
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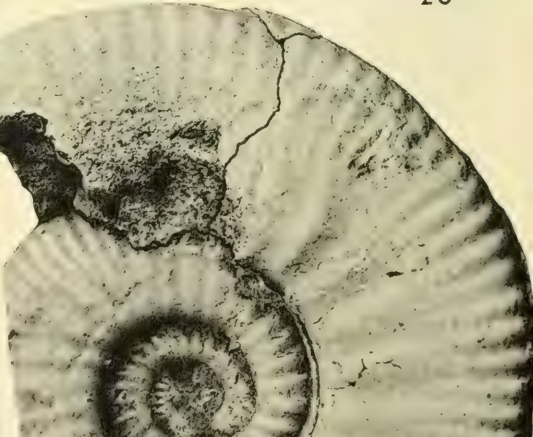
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Explanation of Plate 55

Natural size if not otherwise indicated.

Figure Page

1-4. **Erycitoides howelli** (White) 360

Kialagvik formation, Loc. A 8 in Upper *E. howelli* Zone (float), Wide Bay.

1. Internal mold with somewhat deformed body chamber fragment, possible not fully grown; inner whorls with irregular, generally strong primaries and lateral spines, but the costation is laterally weak on the ultimate whorl of the phragmocone. U.W. 16789. 2 a,b. Internal mold of compressed and involute inner whorls; tubercles present on the nucleus; on the last whorl the costae became fine and irregularly fasciculate; the keel is prominent. U.S. 16790. 3. Phragmocone with beginning of body chamber, test preserved on inner whorls; costation typically fasciculate. U.W. 16791. 4. Internal mold of phragmocone, laterally compressed by deformation; costation showing defined primaries and secondaries as in typical *E. howelli,* though somewhat finer. U.W. 16792.

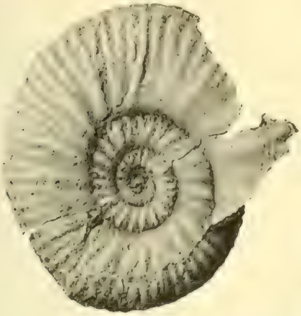
Explanation of Plate 56

Natural size if not otherwise indicated.

Figure		Page
1-8b.	**Erycitoides howelli** (White)	360

Kialagvik formation, Upper *E. howelli* Zone, Wide Bay.

1. Internal mold of inner whorls, somewhat deformed; costae somewhat fasciculate. Loc. A 8. U.W. 16593. 2 a,b. Internal mold of inner whorls; fine lateral tubercles present on the nucleus, keel prominent. Loc. A 8. U.W. 16594. 3 a,b. Internal mold of inner whorls; nontuberculate, keel obsolescent. Loc. A 8. U.W. 16595. 4 a,b. Internal mold of inner whorls; whorl section compressed, somewhat rectangular, costation fasciculate, keel blunt and weak. Loc. A 8, U.W. 16596. 5 a,b. Internal mold of inner whorls, slightly deformed; whorl section subcircular, primaries strong and with tubercles on nucleus, costae fasciculate on last whorl. Loc. A 8. U.W. 16597. 6. External view on nucleus with prominent keel, whorl section and septum of internal mold. Loc. A 8. U.W. 16598. 7. Internal mold of inner whorl fragments; costation fine and subfasciculate. Loc. L 543. U.W. 16599. 8 a,b. Phragmocone, largely with test, costation typically fasciculate except for ultimate ½ whorl; keel prominent only superficially. Loc. L 543. U.W. 16600.



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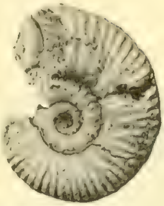

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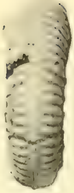

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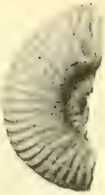

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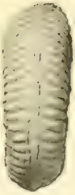

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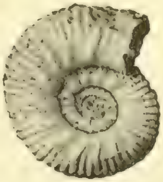

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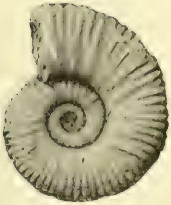

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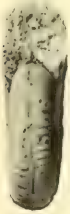

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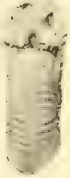

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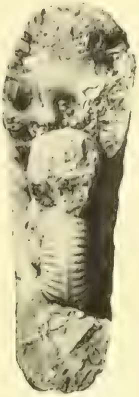

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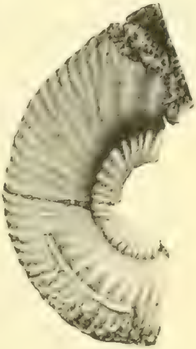

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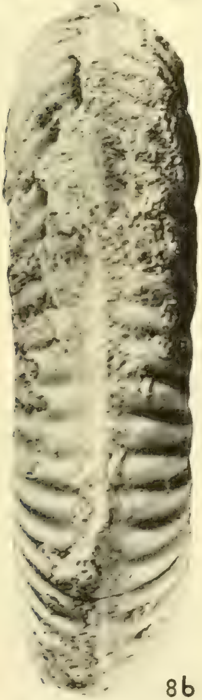

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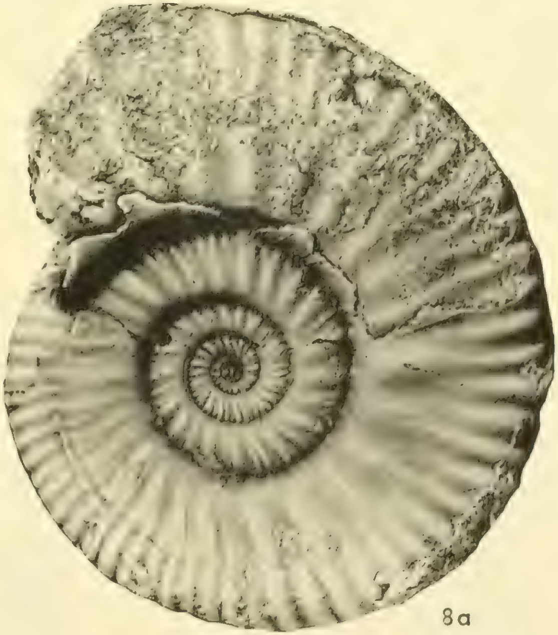

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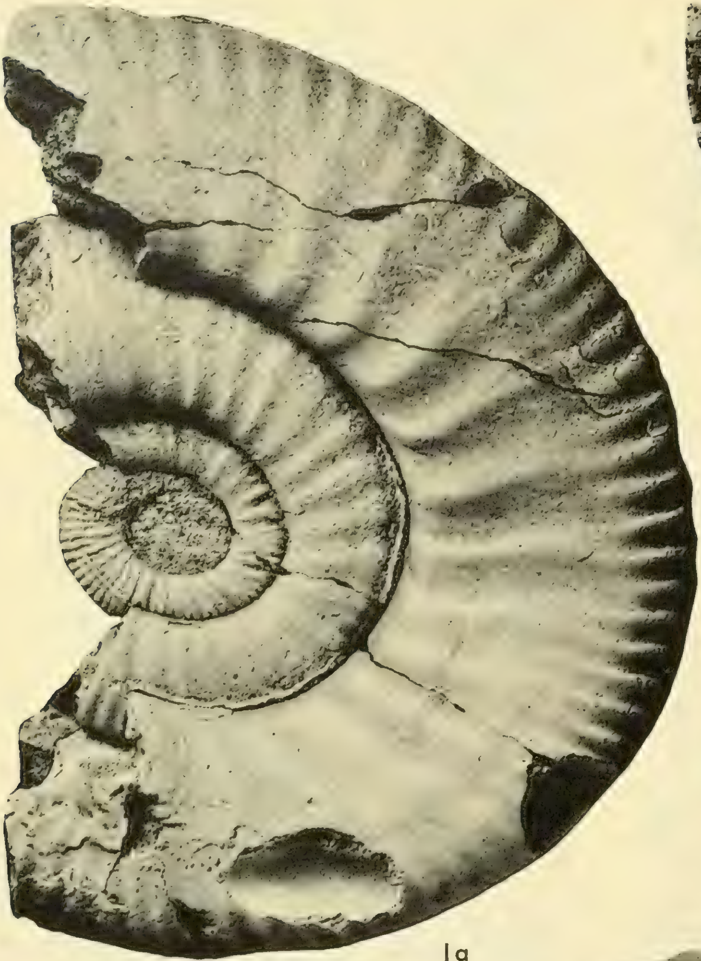

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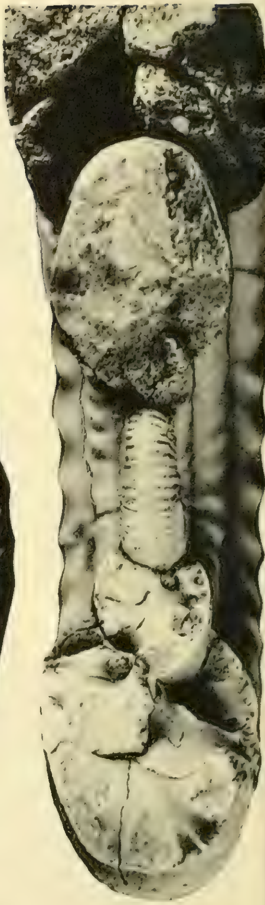

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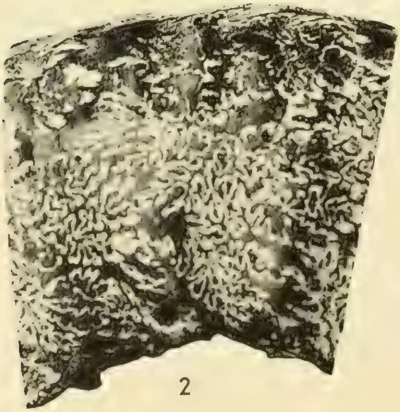

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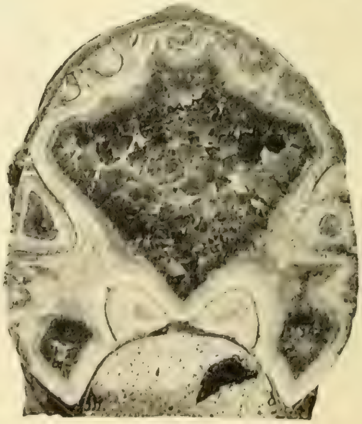

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Explanation of Plate 57

Natural size if not otherwise indicated.

Figure Page

1-3. **Erycitoides howelli** (White) 360

Kialagvik formation, Wide Bay.

1 a,b. Internal mold with ½ whorl body chamber, somewhat deformed; probably fully grown; costation irregularly subfasciculate on nucleus, nontuberculate, fine and laterally almost obsolescent on outer whorls, secondaries remarkably densely spaced on body chamber. Near top of *E. howelli* Zone. Loc. L 543. U.W. 16601. 2. Septal sutures at approximately 150 mm. diameter. Loc. A 444 in *E. howelli* zonule. U.W. 16602. 3. Polished cross section, showing test thickening in keel; X 2.1. Same locality. U.W. 16603.

Explanation of Plate 58

Natural size if not otherwise indicated.

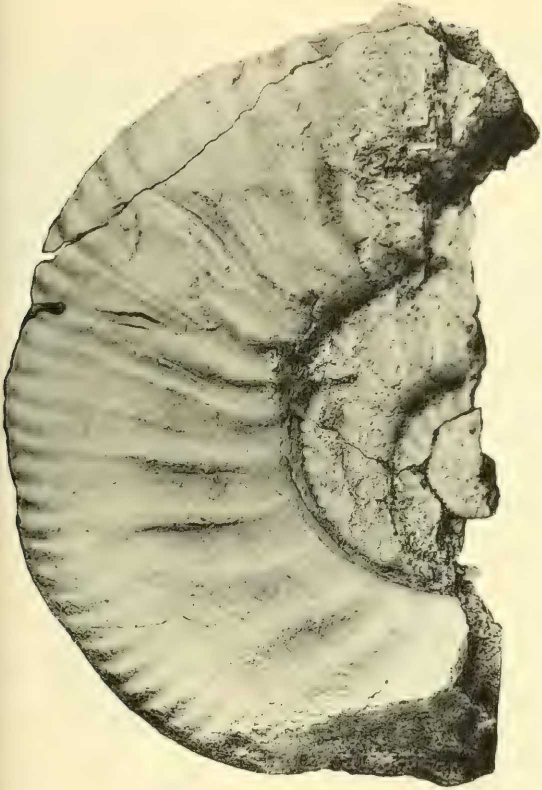
Figure Page

1. **Erycitoides howelli** (White) 360

Fragmentary internal mold with apertural constriction, inner whorls deformed, fully grown; primaries weak but long, secondaries densely spaced on body chamber. Kialagvik formation. Loc. L 543 near top of *E. howelli* Zone, Wide Bay. U.W. 16604.

2 a,b. **Erycitoides profundus** Westermann, sp. nov. 378

Fragmentary internal mold of phragmocone and beginning of body chamber which is deformed by lateral compression. The densely spaced secondaries almost reach the rather prominent keel. Kialagvik formation. Loc. A 86 in the *E. teres-profundus* zonule, Wide Bay. U.W. 16605.



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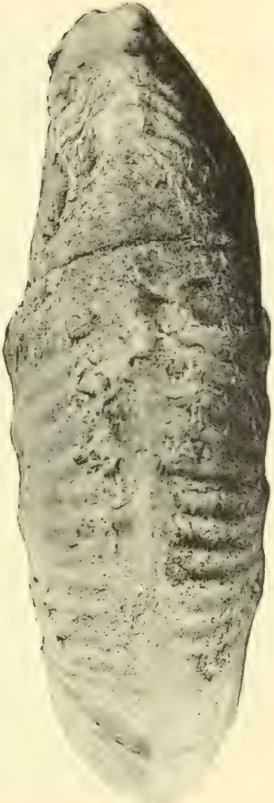

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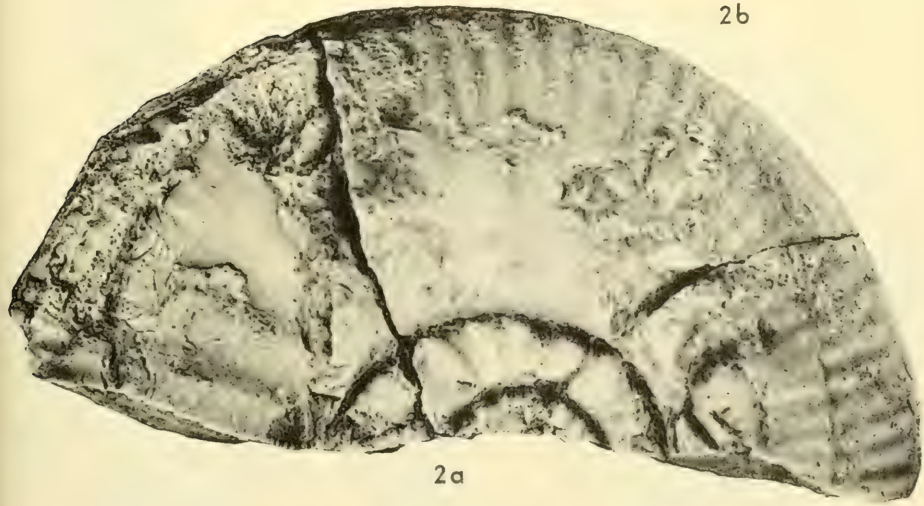

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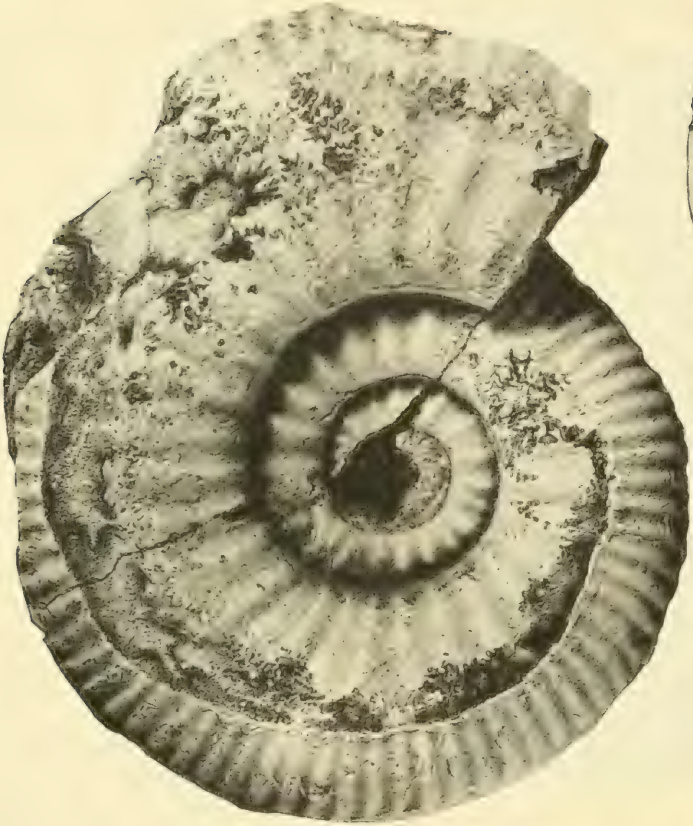

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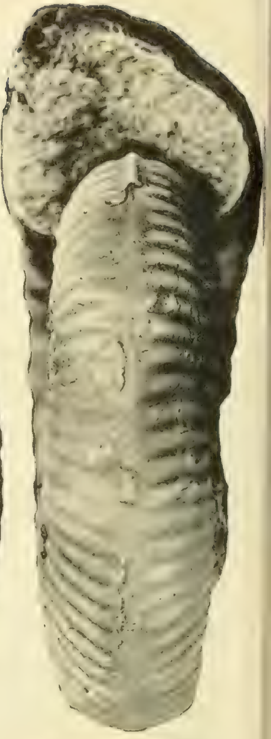

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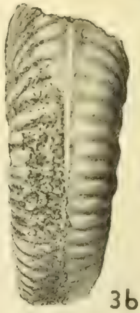

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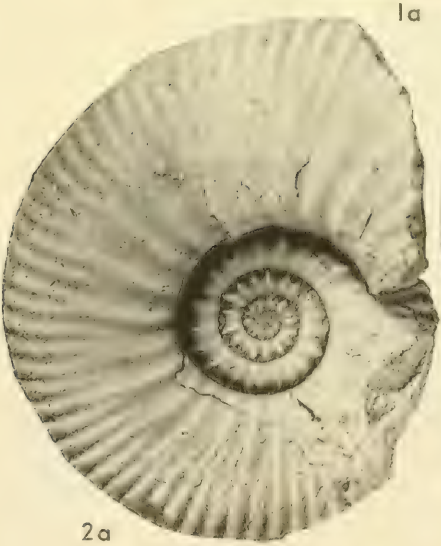

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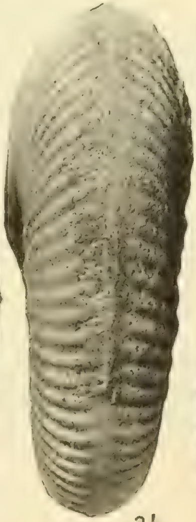

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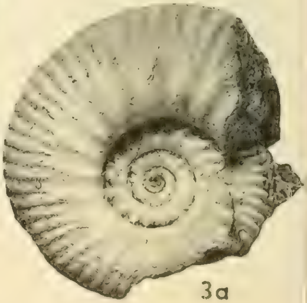

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Explanation of Plate 59

Natural size if not otherwise indicated.

Figure		Page
1-3b.	**Erycitoides profundus** Westermann. sp. nov.	378

Kialagvik formation, *E. teres-profundus* zonule, Wide Bay.

1 a,b. Holotype; internal mold with test remains of phragmocone, partly strongly corroded; prominent solid keel of test partly preserved (1b). Loc. L 1067. U.W. 16606. 2 a,b. Internal mold with test on inner whorls, totally septate (see Pl. 57, fig. 2). Loc. A 454. U.W. 16607. 3 a,b. Inner whorls with test, partly corroded. Loc. L 1067. U.W. 16608.

Explanation of Plate 60

Natural size if not otherwise indicated.

Figure Page

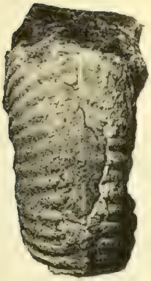
1. **Erycitoides** cf. **E. profundus** Westermann, sp. nov. 378

End of body chamber with complete (left) peristome, internal mold. Kialagvik formation. Loc. A 454 in *E. teres-profundus* zonule, Wide Bay. U.W. 16609.

2-6. **Erycitoides teres** Westermann, sp. nov. 380

Kialagvik formation, *E. teres-profundus* zonule, Wide Bay.

2. *E.* cf. *E. teres,* fragment of phragmocone with test remains. Loc. 48 A$_1$-86 (21245((=F12). U.S.N.M. 132025. 3 a,b. *E.* cf. *E. teres,* juv.? (or inner whorls); test largely preserved. Loc. A 454. U.W. 16610. 4. *E. teres* (?), ¾ whorl body chamber and end of phragmocone, internal mold, strongly compressed by deformation. Loc. A 7. U.W. 16611. 5 a,b. Holotype, fully septate, inner whorl with test, compressed by deformation; thin prominent costae on innermost whorl, becoming blunt and laterally almost obsolete on next whorls. Loc. A 454. U.W. 16612. 6. *E.* cf. *E. teres,* phragmocone fragment. Same locality as figure 2. U.S.N.M. 132026.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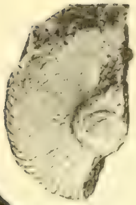
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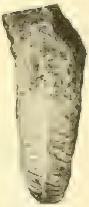
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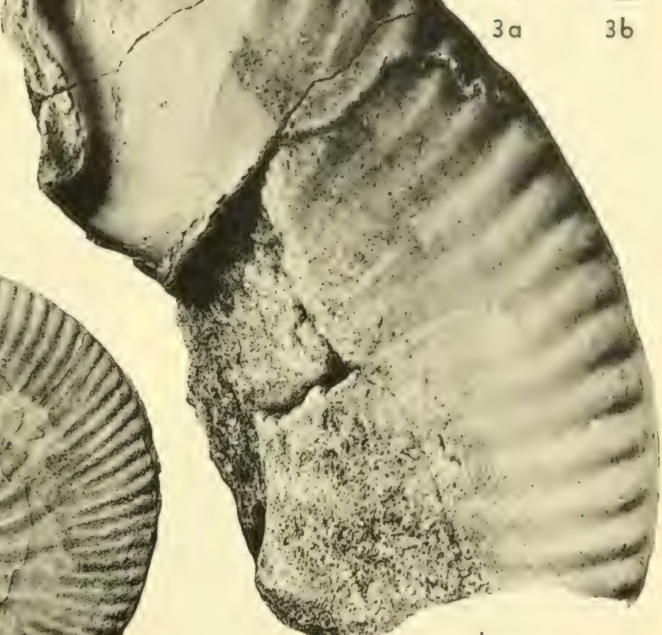
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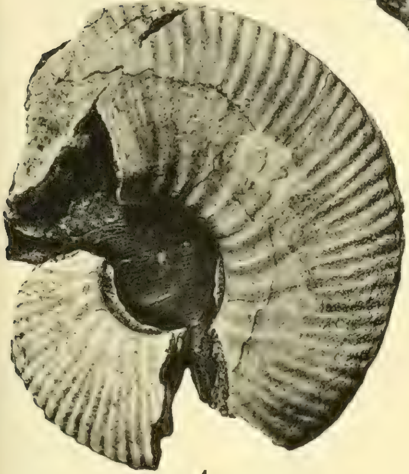
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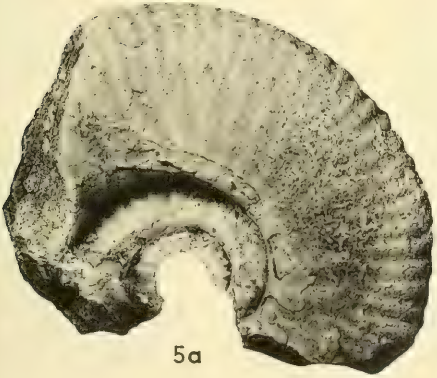
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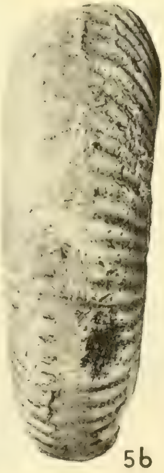
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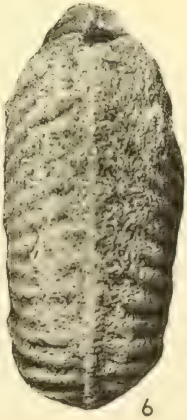
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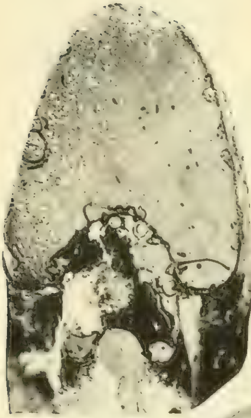
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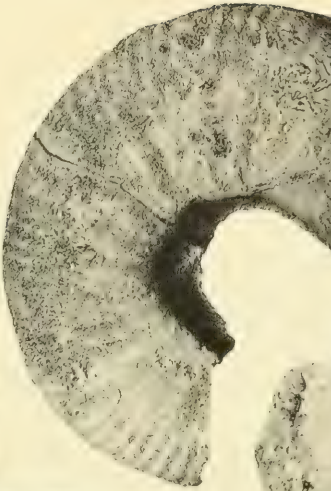
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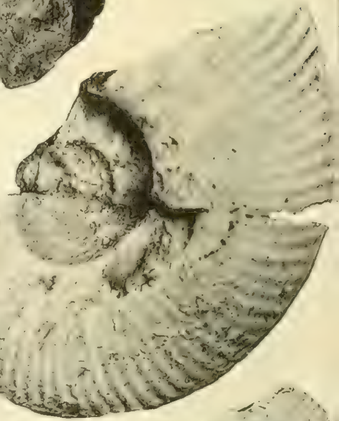
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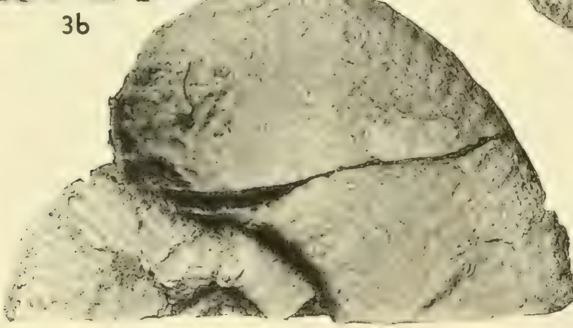
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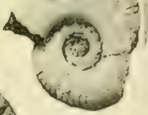
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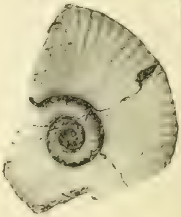
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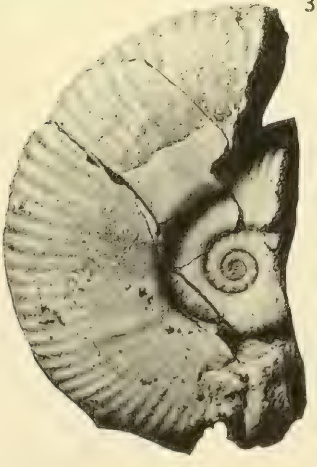
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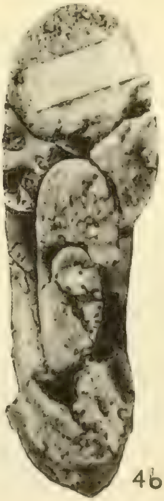
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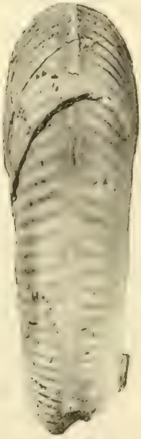
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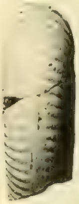
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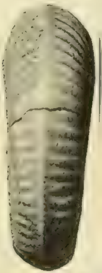
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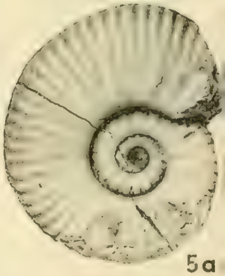
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Explanation of Plate 61

Natural size if not otherwise indicated.

Figure Page

1-3b. **Erycitoides teres** Westermann, sp. nov. 380

Kialagvik formation, *E. teres-profundus* zonule, Wide Bay

1. *E. teres* (?), internal mold of phragmocone fragment, somewhat compressed. Loc. 48 A_1-86 (21245) (=F12). U.S.N.M. 132027. 2. Fragmentary internal mold of phragmocone, strongly compressed by deformation. Loc. A 86. U.W. 16613. 3 a,b. Fragmentary internal mold of phragmocone with some test remains, not deformed except for exposed parts of inner whorls; polished cross section (3b). Loc. A 86. U.W. 16614.

4 a-f. **Erycitoides teres compressus** Westermann, subsp. nov 382

Holotype; internal mold of phragmocone, minor test remains. 4 d-f. Inner whorls of same specimen. Kialagvik formation, Upper *E. howelli* Zone, Wide Bay. Loc. F 54 (19784). U.S.N.M. 132028.

5 a,b. **Erycitoides** sp. nov.?, juv. aff. **E. teres** sp. indet 383

Almost complete internal mold, phragmocone largely with test, last sutures not approximated, body chamber, aperture missing. Kialagvik formation, *E. teres-profundus* zonule. Wide Bay. Loc. $48A_1$-86 (21245) (=F12). U.S.N.M. 132029.

Explanation of Plate 62

Natural size if not otherwise indicated.

Figure Page

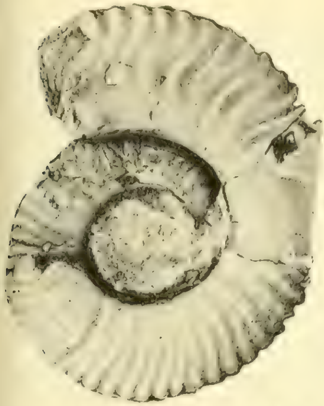
1-6c. **Erycitoides (Kialagvikes) kialagvikensis** (White) 392

Kialagvik formation, Wide Bay.

1 a,b. Holotype (plastotype); adult specimen, ¾ whorl body chamber with partially preserved aperture, only right side deformed, ultimate ½ whorl of phragmocone strongly compressed by deformation. Wide Bay (labelled "Wrangel Bay"), *E. howelli* Zone, *E. howelli* zonule. (U.S.G.S. Loc. 20086). U.S.N.M. 132030. 2 a,b. Complete body chamber with test, peristome missing, phragmocone as imprint or strongly deformed (compressed); externside smooth, finally crossed by weak chevrons. Loc. F 37 (19767), *E. howelli* zonule. U.S.N.M. 132031. 3. Internal mold with test on phragmocone, complete with peristome; costation irregularly fasciculate on phragmocone. Loc. 48 A_1-105 (21253) in Upper *E. howelli* Zone. U.S.N.M. 132032. 4 a,b. Internal mold with test remains, complete with peristome; costation fasciculate, keeled up to aperture. Loc. A 11 in *E. tenue-flexicostatum* zonule. U.W. 16615. 5 a-d. Internal mold with complete peristome, phragmocone strongly deformed, body chamber slightly deformed; 5a×0.9; 5 c,d×2: lateral and external lateral view of same aperture showing right and left lappet. Loc. A 8 in upper *E. howelli* Zone. U.W. 16616. 6 a-c. Internal mold with complete peristome featuring large spoon-shaped lappets; body chamber slightly, phragmocone strongly deformed; costation largely flattened by deformation; 6c×2. Loc. L 543 in Upper *E. howelli* Zone. U.W. 16617.

7. **Praestriaptychus** (subgen. nov.?) **antiquus** Westermann, sp. nov. 387

Holotype, almost complete right valve with test remains, superimposed on fragment of left valve; found in association with body chamber of *E. kialagvikensis* but obviously too large. (See Pl. 73, figs. 12 a,b). Loc. A 85 in the *E. teres-profundus* zonule. U.W. 16618.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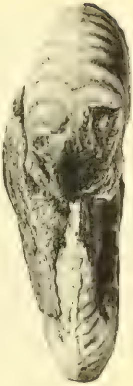
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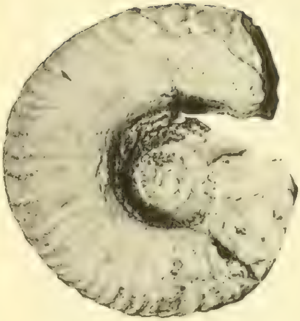
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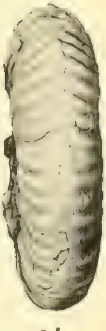
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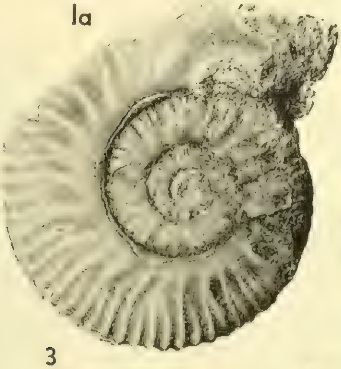
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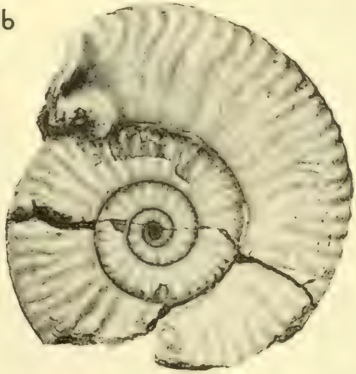
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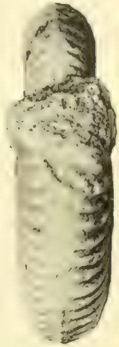
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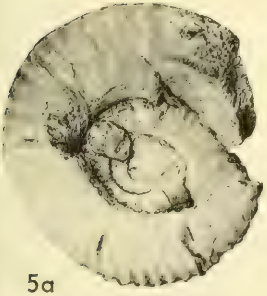
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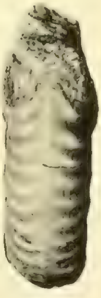
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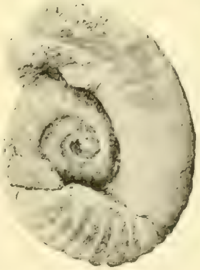
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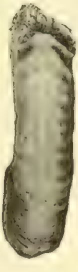
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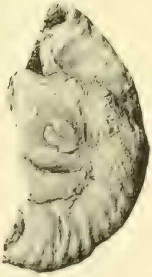
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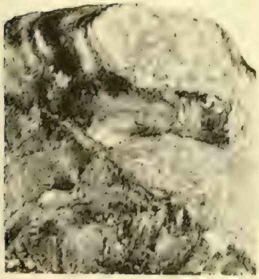
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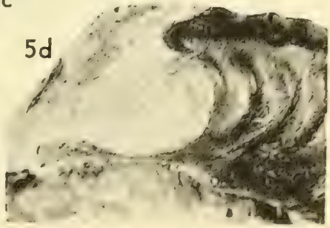
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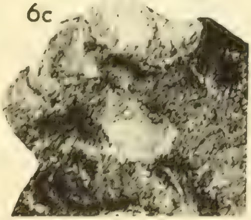
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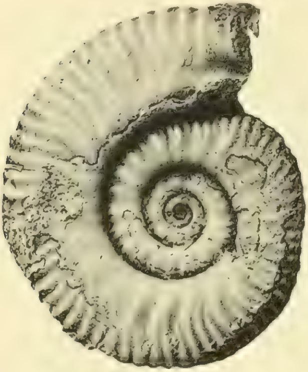

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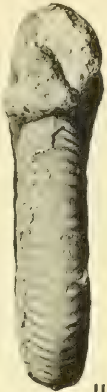

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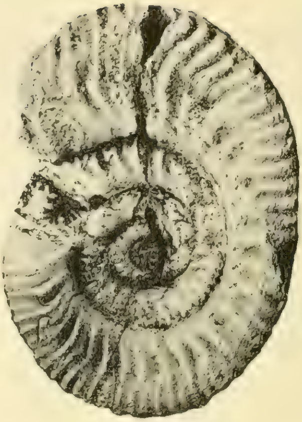

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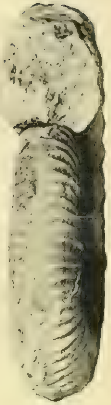

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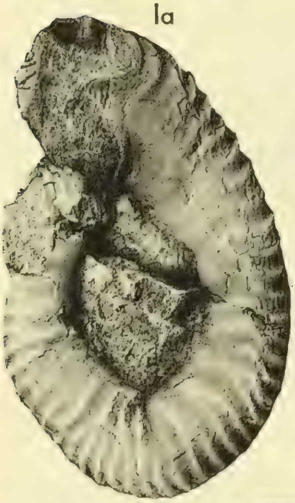

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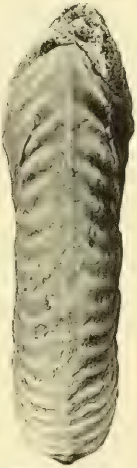

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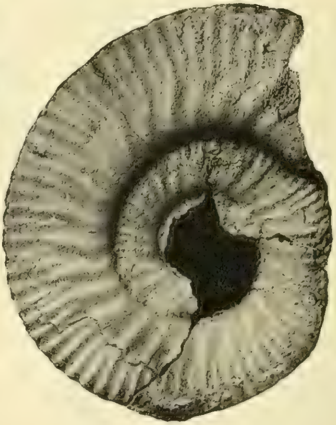

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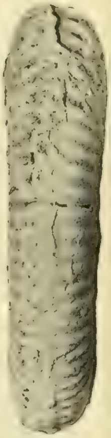

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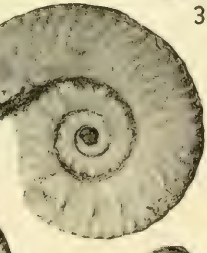

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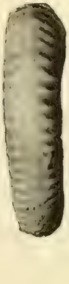

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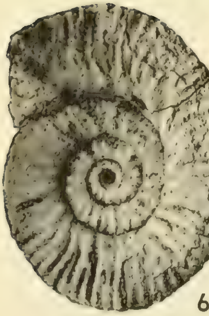

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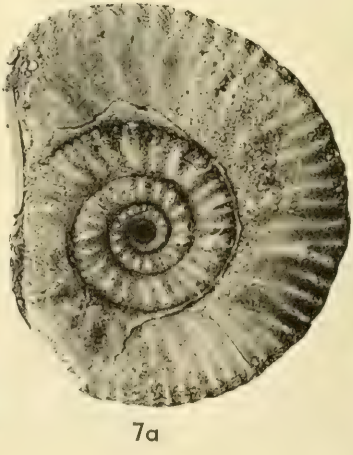

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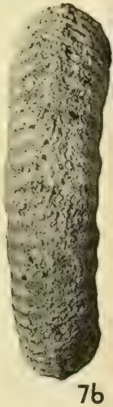


7b

Explanation of Plate 63

Natural size if not otherwise indicated.

Figure		Page
1-7b.	**Erycitoides (Kialagvikes) kialagvikensis** (White)	392

Kialagvik formation, Wide Bay.

1 a,b. Well-preserved complete specimen, largely with test. Costation typically fasciculate. Loc. F 59 (19789) in Upper *E. howelli* Zone. U.S.N.M. 132033. 2 a,b. Complete deformed specimen with traced septal suture; costation subfasciculate. Loc. L 543 in Upper *E. howelli* Zone. U.W. 16619. 3 a,b. Complete large deformed body chamber with test remains. Loc. A 10 in Upper *E. howelli* Zone. U.W. 16620. 4 a,b. Almost complete compressed variant with fasciculate costation. Loc. A 447 in *E. howelli* zonule. U.W. 16621. 5 a,b. Complete small finely spinose variant; phragmocone with test, body chamber as internal mold. Loc. A 454 in *E. teres-profundus* zonule. U.W. 16622. 6. Completely finely spinose variant, internal mold, deformed; nucleus with lateral spines, ultimate 1/2 whorls with subfasciculate costation. Loc. A 8 in Upper *E. howelli* Zone. U.W. 16623. 7 a,b. Same variant; almost complete internal mold, not deformed. Loc. F 35 (19766) in *E. howelli* zonule. U.S.N.M. 132034.

Explanation of Plate 64

Natural size if not otherwise indicated.

Figure Page

1-6. **Erycitoides (Kialagvikes) spinatus** Westermann, sp. nov. 397

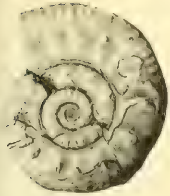
Kialagvik formation, Middle (F12) and Upper *E. howelli* Zone, Wide Bay.

1 a,b. Holotype; internal mold of phragmocone and ½ whorl incomplete body chamber. Loc. A 8, U.W. 16624. 2. Rubber cast of natural impression. Originally identified as "*Hammatoceras*" (Imlay, 1952, p. 978, para. 68). Loc. F 12 (19747). U.S.N.M. 132035. 3. *E. spinatus* (?); almost complete specimen with test, largely compressed by deformation. Possibly an adolescent *E. howelli*. Originally identified as "*Sonninia* sp." (Imlay, 1952, p. 978. para. 68). Loc. 48 A_1-109 (21254). U.S.N.M. 132036. 4 a,b. *E. spinatus* ? Almost complete, slightly deformed internal mold with ½ whorl body chamber, test remains. Possibly an extreme spinose variant of *E. kialagvikensis*. Loc. A 8. U.W. 16625. 5 a,b. *E. spinatus ?* Internal mold of body chamber fragment with complete peristome bearing a large spoon-shaped lateral lappet. Loc. 48 A_1-86 (21245 = F12). U.S.N.M. 132037. 6. Cf. *E. spinatus*. Internal mold of fragmentary phragmocone and 1/4 body chamber, laterally compressed by deformation. Same location as fig. 5. U.S.N.M. 132038.

7-12b. **Erycitoides (Kialagvikes) levis** Westermann, sp. nov. 399

Kialagvik formation, probably all from *E. teres-profundus* zonule, Wide Bay.

7 a-e. Holotype; internal mold of compressed phragmocone fragment and 3/5 whorl body chamber with aperture; 7a×1; 7b×1.2; 7c×1.8: internal mold; 7d×1; 7e×1.9: rubber cast of natural mold, reversed, with lappet. Loc. A 85. U.W. 16626. 8. Fragment with beginning of body chamber, test. Loc. A 454. U.W. 16627. 9 a,b. Internal mold, almost complete but aperture missing; keel partly exaggerated by slight lateral deformation. For cross section see Text-figure 19b. Loc. A 9 (?). U.W. 16628. 10. Same, with almost total resemblance; ×1.2. Loc. A 9. U.W. 16629. 11. Strongly laterally deformed internal mold, apparently with complete peristome; lappet either not yet developed or broken off parallel to growth lines; few blunt bullae on the inner whorls. Loc. A 85. U.W. 16630. 12 a,b. *E. levis* ?; almost complete well-preserved specimen, with test on phragmocone, 3/5 whorl body chamber as internal mold; costation weak, fasciculate. This is possibly an extreme variant of *E. kialagvikensis*. Loc. A 454. U.W. 16631.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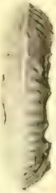
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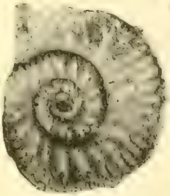
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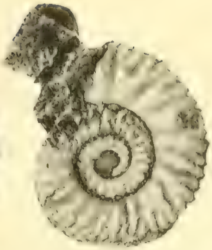
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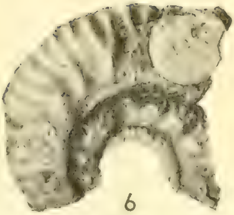
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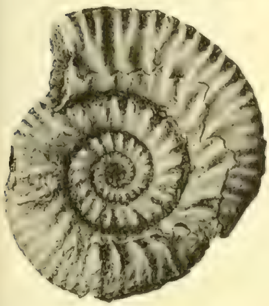
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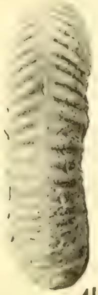
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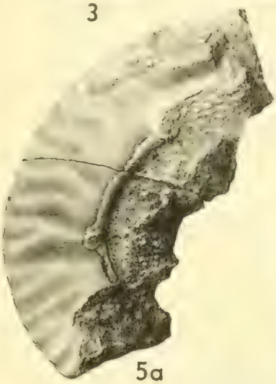
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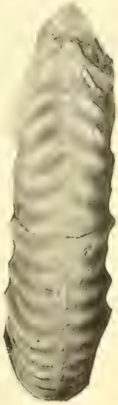
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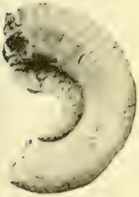
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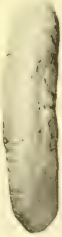
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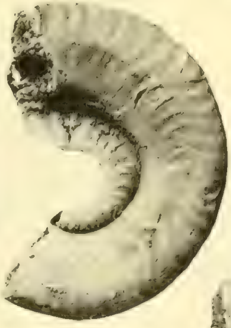
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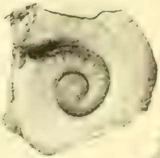
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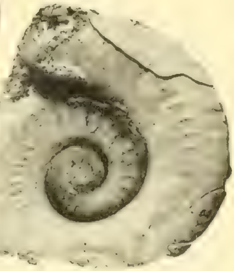
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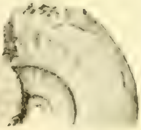
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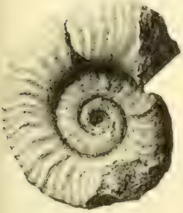
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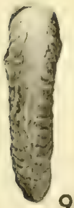
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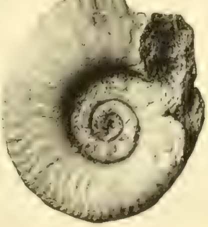
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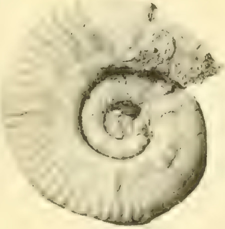
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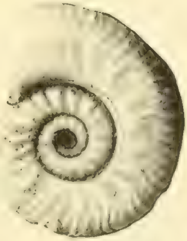
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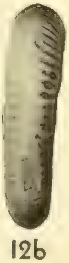
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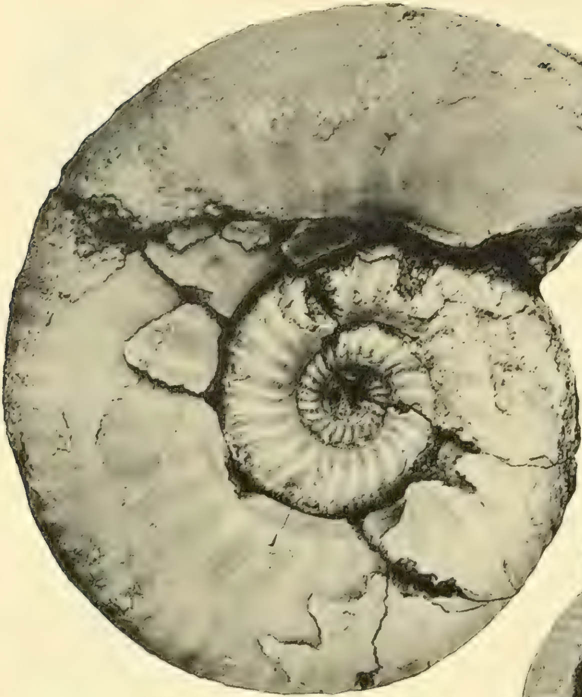

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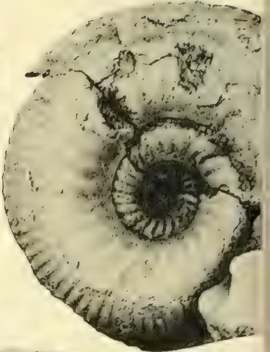

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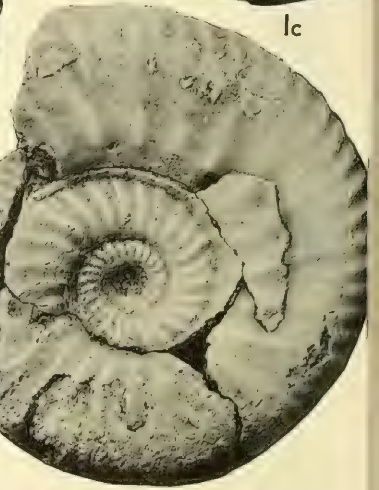

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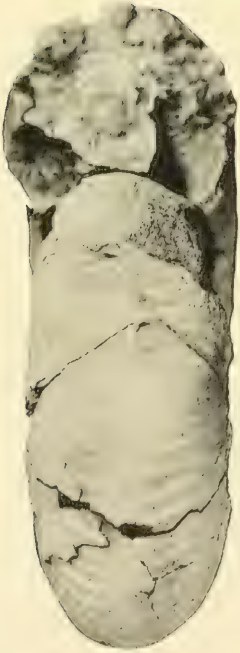

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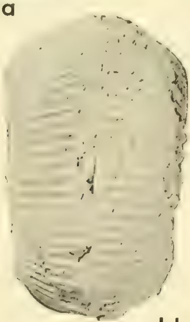

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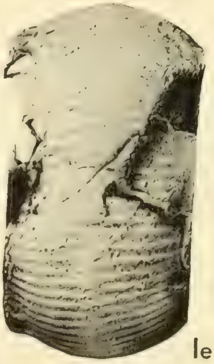

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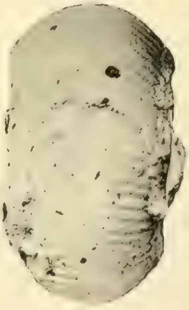

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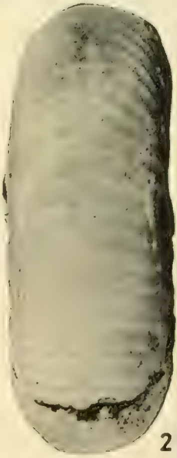


2b

Explanation of Plate 65

Natural size if not otherwise indicated.

Figure Page

1-2c. **Erycites imlayi** Westermann, sp. nov. 400

Loc. $48A_1$-95 (21246). Kialagvik formation, *E. howelli* zonule, Wide Bay.

1 a-e. Holotype; complete internal mold, test remains with almost 3/4 whorl body chamber, aperture with fragment of thick test in broad construction (1a). 1 c. Inner whorls after removal of ultimate whorl. 1 d,e. External views of same internal mold with test remains and plaster cast of its impression showing fine superficial keel. U.S.N.M. 132039. 2 a-c. Incomplete specimen with ½ whorl body chamber, internal mold, phragmocone largely with test. 2 c. External view of phragmocone, with test in upper part, after removal of body chamber. U.S.N.M. 132040.

Explanation of Plate 66

Natural size if not otherwise indicated.

Figure Page

1-2c. **Abbasites platystomus** Westermann, sp. nov 405

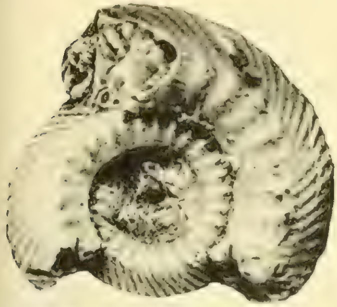
Kialagvik formation, *E. howelli* Zone, Wide Bay.

1 a-c. Holotype; totally septate internal mold with some test; the secondaries simply alternate externally on the penultimate whorl, 1 b. And are continuous on the ultimate whorl, 1 c. Septum bullate (1b, see Text-figure 26). Loc. A 444 in *E. howelli* zonule U.W. 16632. 2 a-c. *A. platystomus* (?); two fragments of single deformed internal mold; externside partly broken (2b). Top *E. howelli* Zone. Loc. F 21 (19755). U.S.N.M. 132041.

3-5. **Eudmetoceras nucleospinosum** Westermann, sp. nov. 414

Kialagvik formation, all from Loc. A 22 in the *Eudmetoceras* zonule of Wide Bay.

3 a,b. Holotype; probably totally septate, well-preserved fragment, partly with test. U.W. 16633. 4 a-d. Totally septate internal mold, ultimate 1/4 whorl on the left side (4b) with test; 4d×2, showing high hollow-floored keel. U.W. 16634. 5. Paratype; rubber cast of natural mold, with approximately 1/4 whorl body chamber. U.W. 16635.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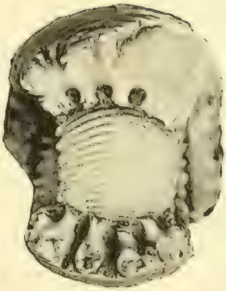
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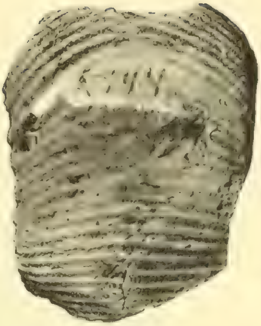
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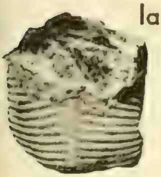
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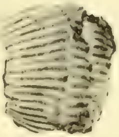
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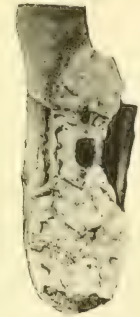
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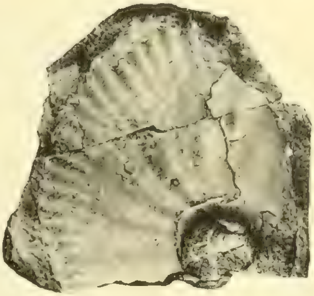
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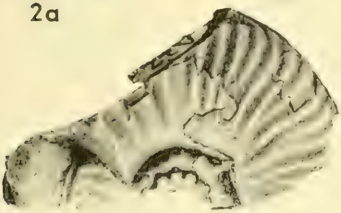
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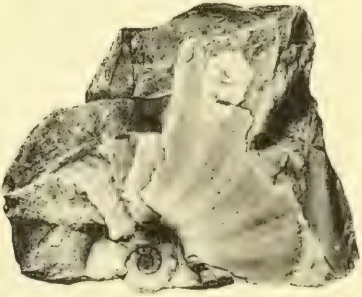
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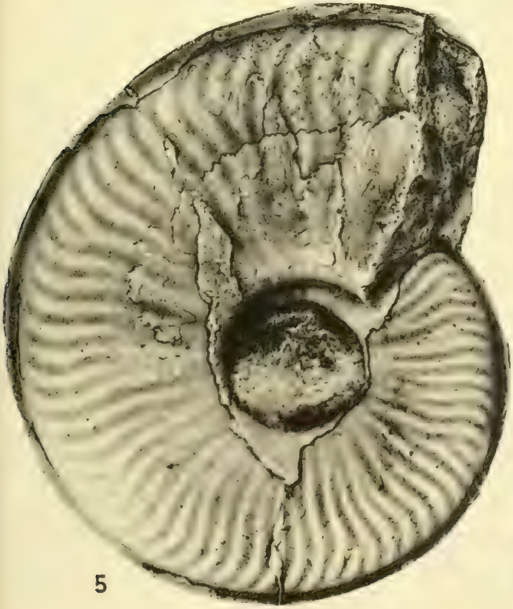
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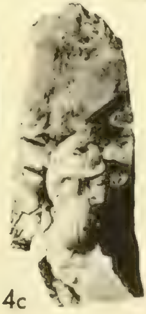
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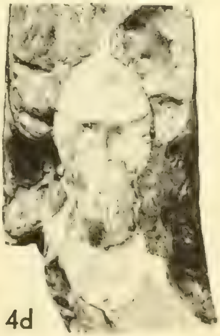
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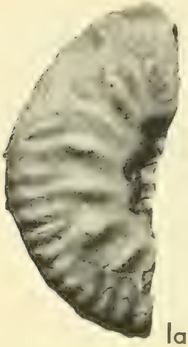
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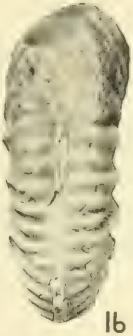
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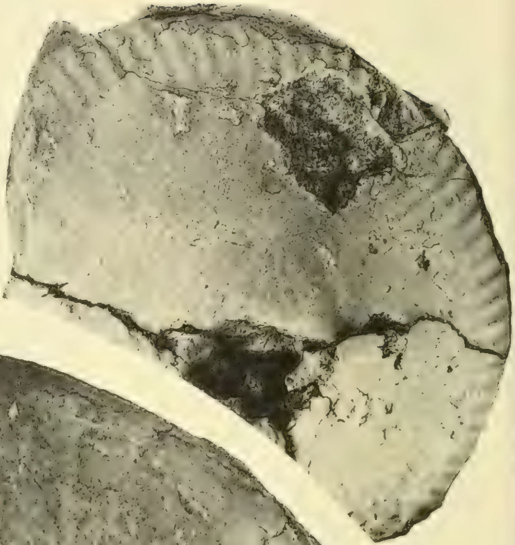
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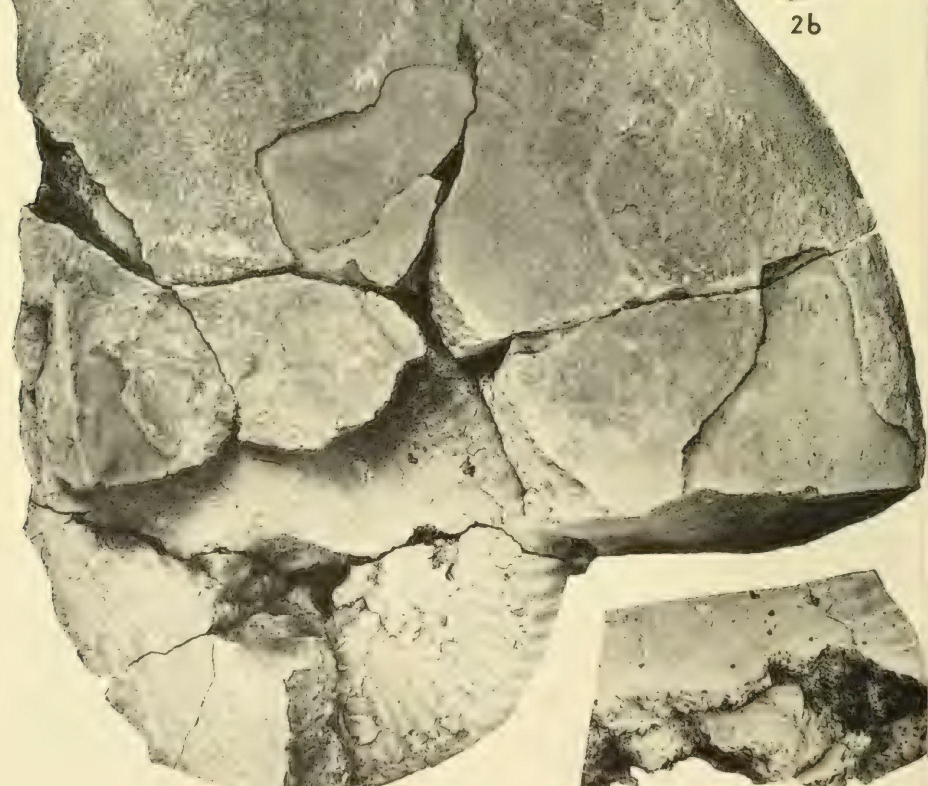
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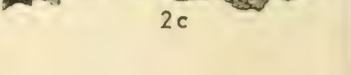
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Explanation of Plate 67

Natural size if not otherwise indicated.

Figure		Page
1 a,b.	**Eudmetoceras** cf. **E. eudmetum jaworskii** Westermann, sp. nov.	412
	Fragmentary internal mold of phragmocone with few test remains; hollow-floored keel broken off. Kialagvik formation. Loc. F 58 (19788) in the *Eudmetoceras* zonule, Wide Bay. U.S.N.M. 132042.	
2 a-c.	**Eudmetoceras (Euaptetoceras) amplectens** (Buckman)	416
	Large almost complete specimen, partly with test, first half of body chamber largely missing. 2 b. Body chamber fragment removed. 2c. Poorly preserved nucleus visible. Kialagvik formation. Loc. A 447 in the *E. howelli* zonule, Wide Bay. U.W. 16636.	

Explanation of Plate 68

Natural size if not otherwise indicated.

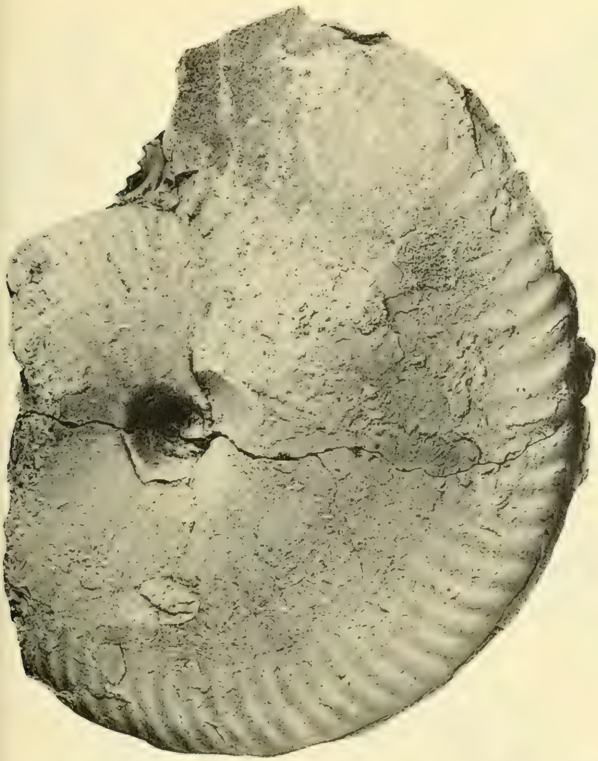
Figure Page

1 a-c. **Eudmetoceras (Euaptetoceras) amplectens** (Buckman) 416

Well-preserved phragmocone, test remains mainly in hollow-floored keel. 1 c. Cross section showing high hollow-floored keel. Kialagvik formation. Loc. A 22 in the *Eudmetoceras* zonule, Wide Bay. U.W. 16637.

2. **Pseudolioceras mclintocki whiteavesi** (White) 421

Internal mold of phragmocone (suture visible) and imperfect beginning of body chamber with test. Same locality and horizon. U.W. 16638.



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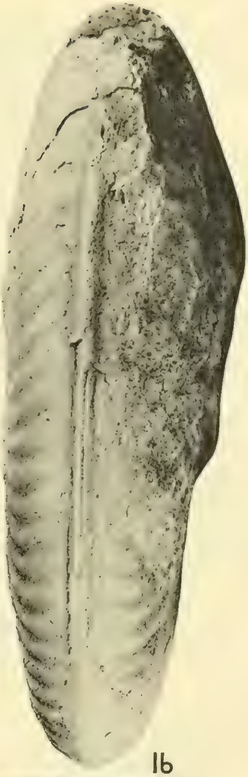

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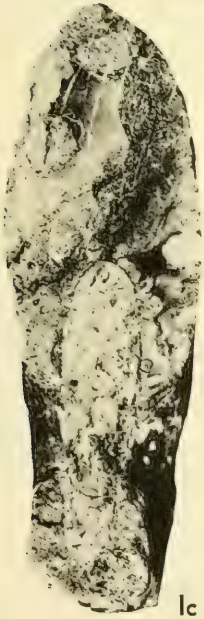

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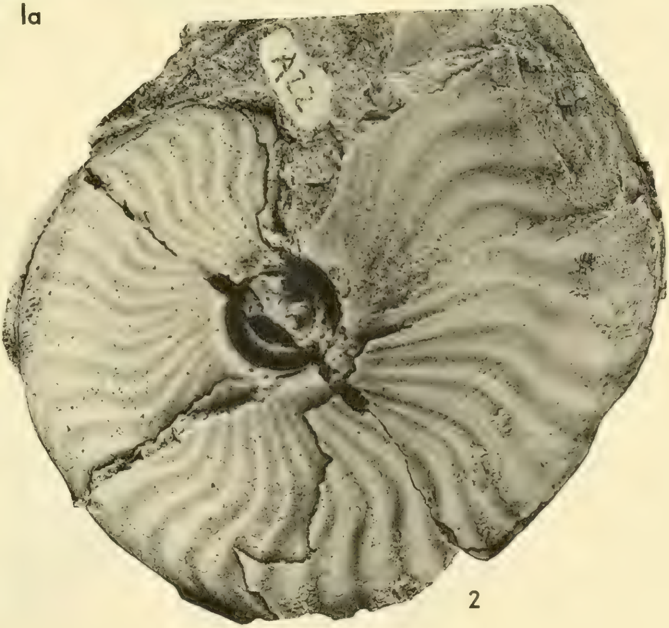

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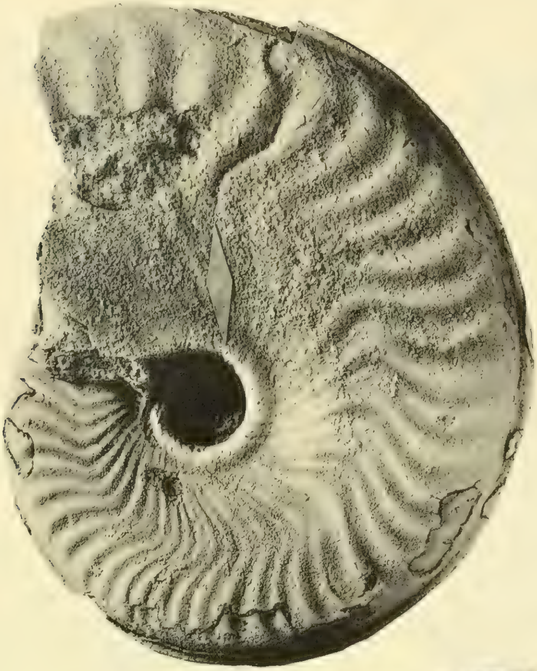

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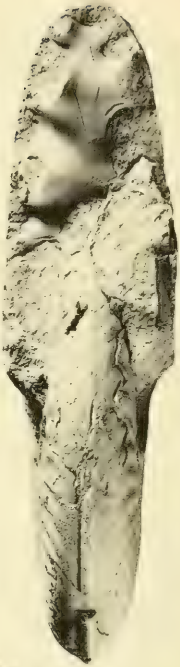

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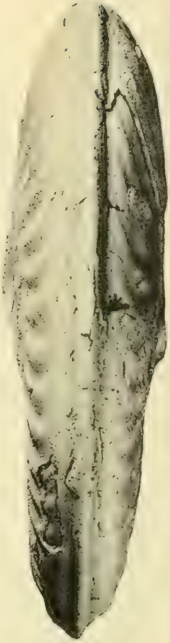

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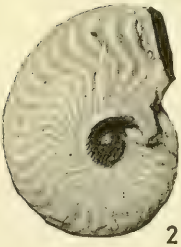

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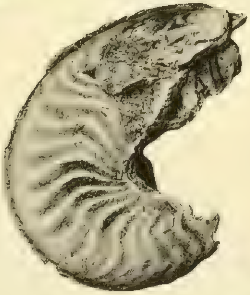

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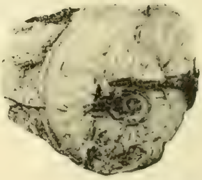

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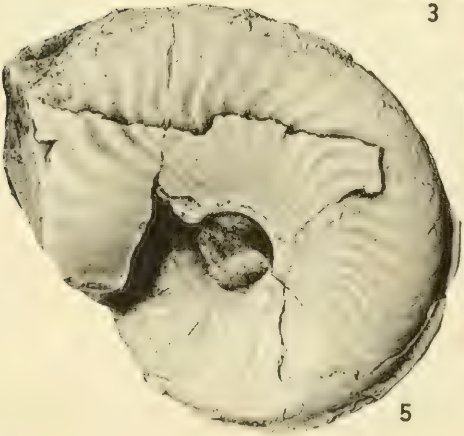

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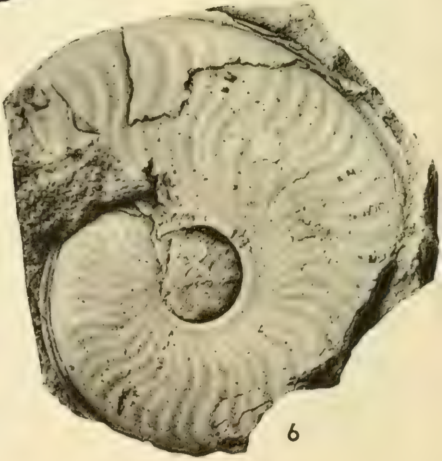


6

Explanation of Plate 69

Natural size if not otherwise indicated.

Figure	Page
1-6. **Pseudolioceras mclintocki whiteavesi** (White)	490

Kialagvik formation, *E. howelli* Zone, Wide Bay.

1 a-c. Lectotype; (plastotype), totally septate specimen, test largely preserved. Probably from *E. howelli* zonule (labelled "Wrangel Bay", U.S.G.S. loc. 20110C). U.S.N.M. 132043. 2. Plastotype of White's (Pl. 13, fig. 4) small "co-type"; inner whorls, showing development of umbilical ridge. Same locality. U.S.N.M. 132044. 3. Body chamber of adolescent specimen, incomplete internal mold, laterally deformed. Loc. A 11 in the *T. tenue-flexicostatum* zonule. U.W. 16639. 4. Inner whorls with test remains, somewhat deformed; umbilical edge developed near end, typical costation and high keel present. Loc. A 446 in the *E. howelli* zonule. U.W. 16640. 5. Phragmocone, some test preserved, hollow-floored keel partly broken off; costation rather fine and umbilical edge developing late. Loc. A 22 in the *Eudmetoceras* zonule. U.W. 16641. 6. Internal mold of densely costate phragmocone. Loc. F 58 (19788) in the *Eudmetoceras* zonule. U.S.N.M. 132045.

Explanation of Plate 70

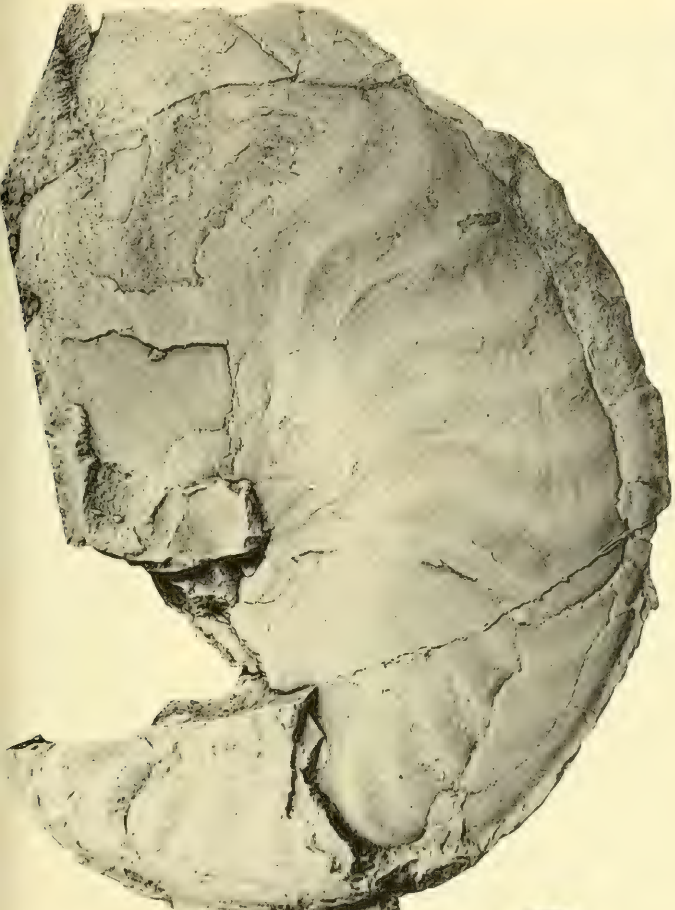
Natural size if not otherwise indicated.

Figure Page

1-4b. **Pseudolioceras mclintocki whiteavesi** (White) 490

Kialagvik formation, Upper *E. howelli* Zone, Wide Bay.

1. Body chamber, largely with test, laterally deformed. Loc. 48 A_1-100 (21259). U.S.N.M. 132046. 2 a,b. Natural cross-fracture of phragmocone with beginning of body chamber; 2 b×2.5, showing hollow-floored keel. Loc. L 543. U.W. 16642. 3 a,b. Totally septate internal mold with test remains. Loc. A 22. U.W. 16643. 4 a,b. Same preservation and locality. U.W. 16644.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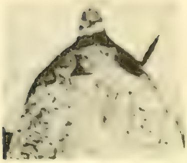
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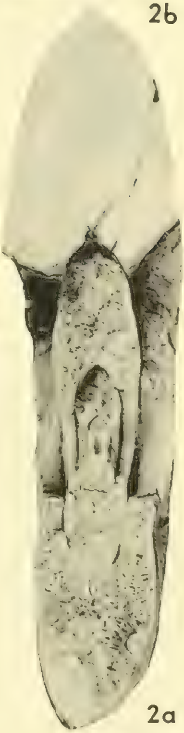
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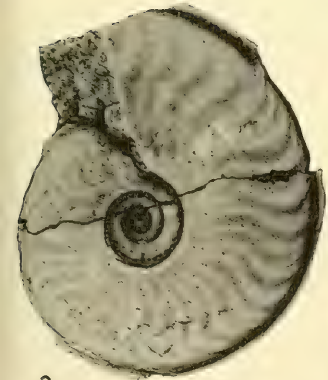
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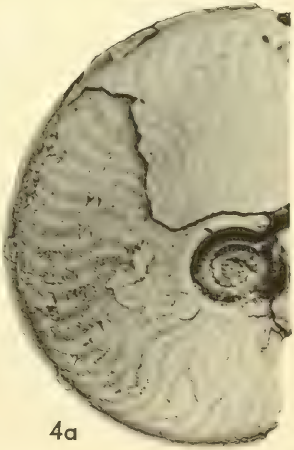
3b

4b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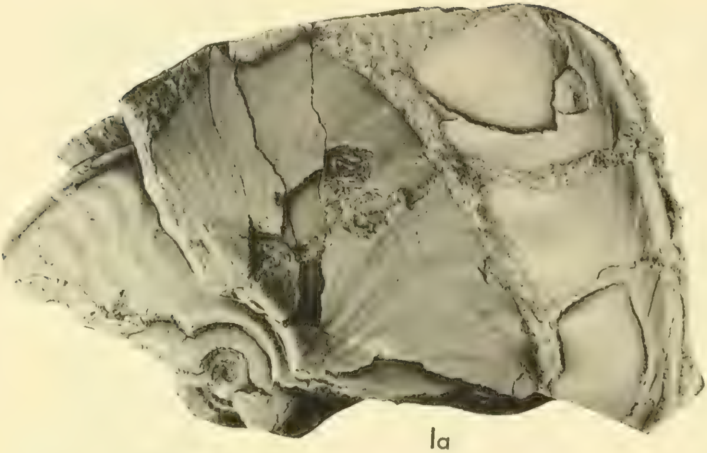
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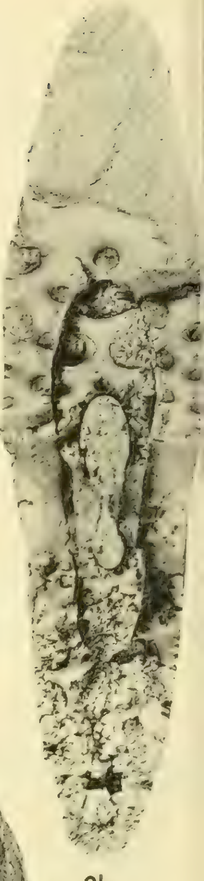
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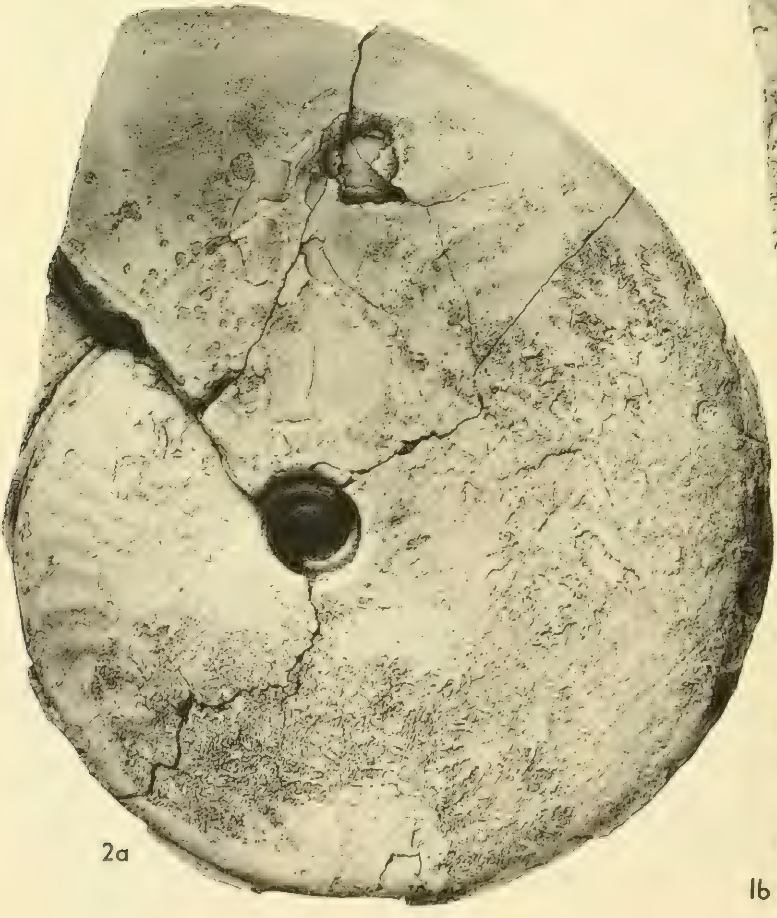
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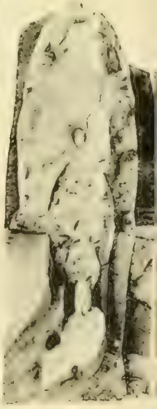
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Explanation of Plate 71

Natural size if not otherwise indicated.

Figure		Page
1-2b.	**Pseudolioceras mclintocki whiteavesi** (White)	490

Kialagvik formation, *E. howelli* Zone, Wide Bay.

1 a,b. Fragment of phragmocone (inner whorl with test) and deformed body chamber (largely with test). 1 a. Showing growth striae. 1 b. Showing whorl sections with umbilical edge and septa of phragmocone. Loc. A 22 in the *Eudmetoceras* zonule. U. W. 16645.
2 a,b. Internal mold of incomplete, largest specimen with only 1/4 whorl fragment of body chamber, hollow-floored keel partly preserved. 2 b. Cross-fracture. Lower *E. howelli* Zone. Loc. I. 285 in the *E. howelli* zonule. U.W. 16646.

Explanation of Plate 72

Natural size if not otherwise indicated.

Figure Page

1-2c. **Tmetoceras scissum** (Benecke) 428

Kialagvik formation, Wide Bay.

1 a,b. Complete internal mold of large specimen, with aperture and several constrictions indicated by arrows, slightly laterally exfoliated; whorl section of body chamber subcircular, of phragmocone compressed oval. Loc. 48 A_1-107, approximately 100 mm. below base of *E. howelli* Zone. U.S.N.M. 132047. 2 a-c. Two body chamber fragments, internal molds, and lateral impression of inner whorls, almost certainly belonging to a single specimen; whorl section subcircular, constrictions indicated by arrows. Same locality and horizon. U.S.N.M. 132048.

3 a, b. **Tmetoceras** sp. juv. 428

Kialagvik formation, Wide Bay.

Phragmocone (and beginning of body chamber?) with test, coarsely costate, whorl section almost subcircular. Loc. L 543 in the Upper *E. howelli* Zone. U.W. 16647.

4-6. **Tmetoceras kirki kirki** Westermann, sp. nov. 437, 439

Kialagvik formation, Wide Bay.

4 a,b. Holotype; internal mold of almost complete specimen with several constrictions, indicated by arrows; costae at end of body chamber pathologic, apparently caused by injury; some costae cross the externside in blunt chevrons. Loc. A 8 in the basal Upper *E. howelli* Zone. U.W. 16648. 5, 6. Rubber casts of natural molds; note the differences in coiling and costation. Same horizon and locality. U.W. 16649, 16650.

7. **Tmetoceras kirki** ?, sp. nov. 441

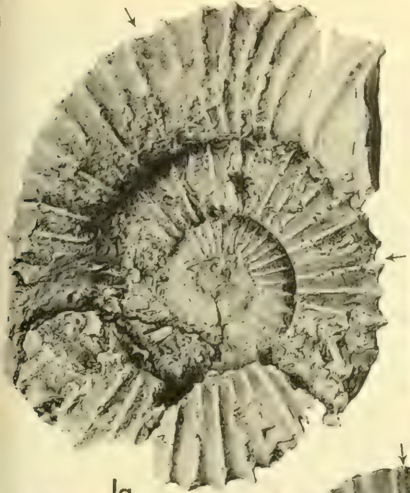
Kialagvik formation, Upper *E. howelli* Zone, Wide Bay.

Somewhat laterally deformed internal mold of phragmocone. Loc. 48 A_1-109 (21254) in the *T. tenue-flexicostatum* zonule. U.S.N.M. 132049.

8-10. **Tmetoceras kirki flexicostatum** Westermann, sp. nov. 440

Kialagvik formation, *T. tenue-flexicostatum* zonule, Upper *E. howelli* Zone, Wide Bay.

8. Holotype; almost complete somewhat laterally deformed internal mold with test remains. Loc. 48 A_1-109 (21254). U.S.N.M. 132050. 9. Rubber cast of large natural impression with ½ whorl body chamber, somewhat deformed; ×0.9. Loc. L 154. U.W. 16651. 10. Internal mold of phragmocone with beginning of body chamber, probably slightly exfoliated; several constrictions on penultimate whorl and changing curvature of costae. Loc. A 11. U.W. 16652.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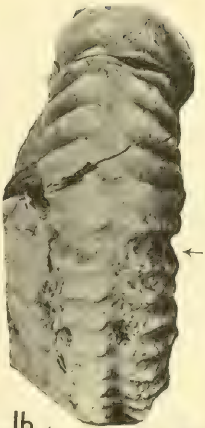
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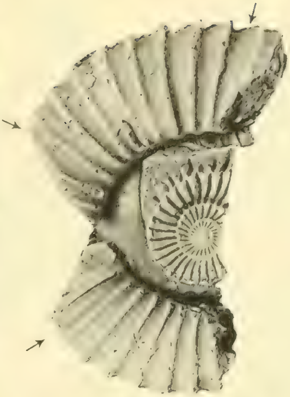
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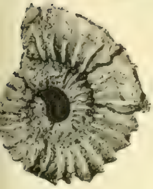
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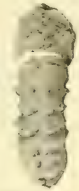
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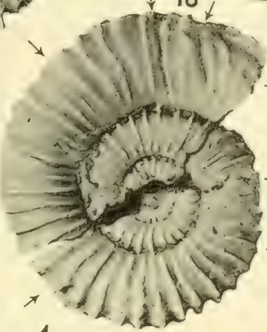
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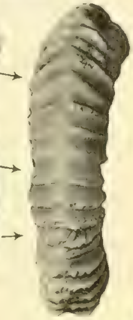
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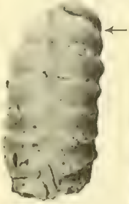
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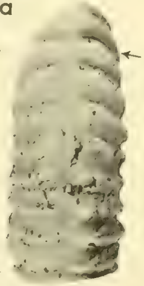
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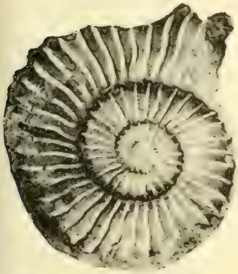
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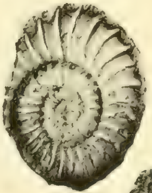
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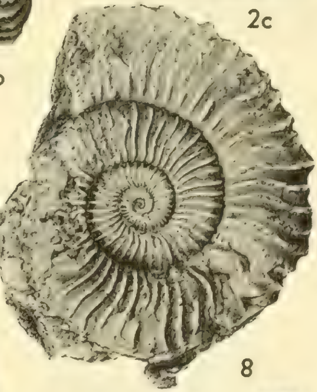
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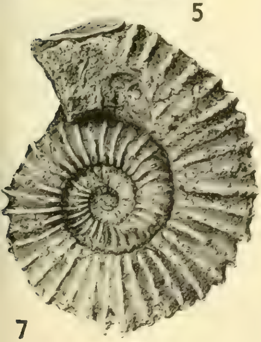
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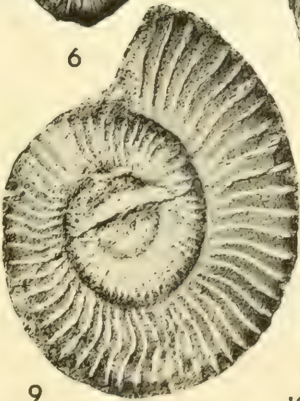
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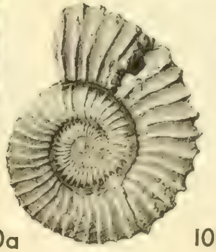
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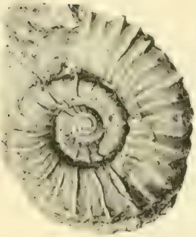
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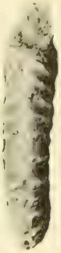
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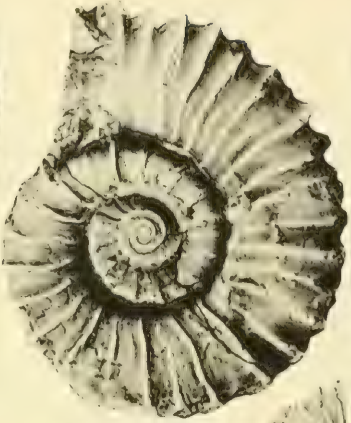
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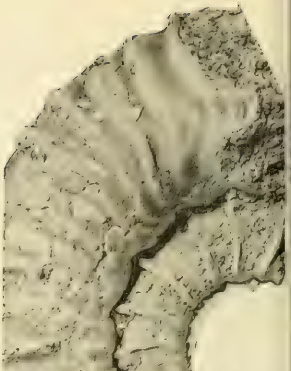
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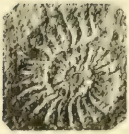
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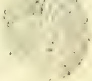
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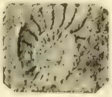
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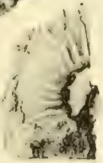
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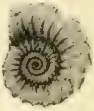
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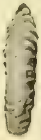
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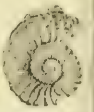
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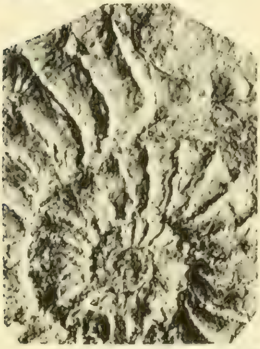
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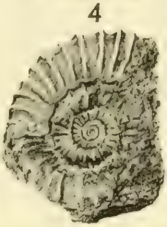
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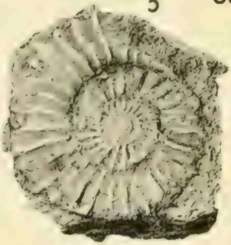
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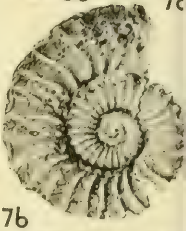
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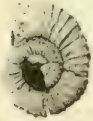
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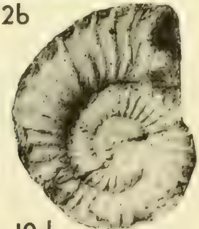
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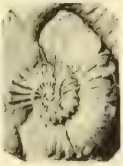
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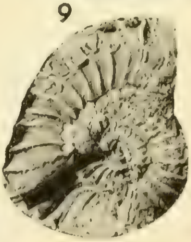
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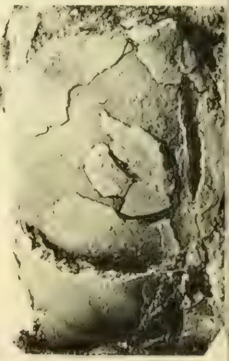
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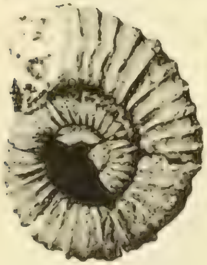
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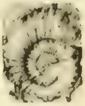
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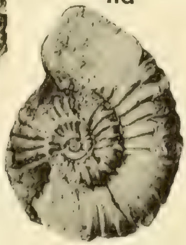
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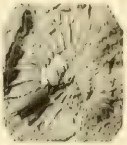
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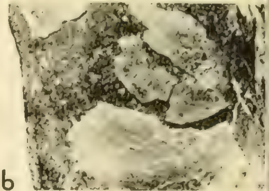
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Explanation of Plate 73

Natural size if not otherwise indicated.

Figure Page

1-9. **Tmetoceras (Tmetoites) tenue** Westermann, sp. nov. 442

Kialagvik formation, Upper *E. howelli* Zone, *T. tenue-flexicostatum* zonule, except for fig. 7; Wide Bay, except for figs. 2 and 3 which are from Puale Bay.

1 a-d. Holotype; complete body chamber, internal mold and ultimate whorl of phragmocone with test, nucleus as impression; 1c×2; 1d×3: showing peristome with lateral lappets and striate phragmocone. Loc. 48 A_1-109 (21254). U.S.N.M. 132051. 2 a-c. *T. tenue* (?), impression of small complete specimen with long lateral lappets; 2a×1.1; 2b-c×4, in natural contrast. Upper *E. howelli* Zone of Puale Bay. Loc. B 128. U.W. 16653. 3. *T. tenue* (?), small complete specimen with short lappet, flattened. Same locality and horizon. U.W. 16654. 4. *T. tenue* (?), small impression. Loc. L 154. U.W. 16655. 5. Fragment of phragmocone and ½ whorl body chamber with costae irregularity (former aperture, *i.e.,* constriction?). Loc. 48 A_1-109 (21254). U.S.N.M. 132052. 6 a,b. Internal mold of phragmocone; 6a×0.9; 6b×1.1. Same horizon and locality. U.S.N.M. 132053. 7 a,b. *T. tenue* (?), internal mold, almost complete; 6b×2.5. Basal Upper *E. howelli* Zone. Loc. A 8. U.A. 16656. 8,9. Two almost complete, deformed internal molds. Loc. 48 A_1-109 (21254). U.S.N.M. 132054, 132055.

10 a-d. **Tmetoceras (Tmetoites),** sp. nov. A 446

Kialagvik formation, Upper *E. howelli* Zone, *T. tenue-flexicostatum* zonule, Wide Bay.

Almost complete internal mold, 10b×2.2; 10c and d×1.9, rubber cast of right impression with peristome. Loc. A 11. U.W. 16657.

11 a-d. **Tmetoceras (Tmetoites)** cf. **T. alpinum** (Thalmann) 445

Kialagvik formation, (Middle?) Upper *E. howelli* Zone, Wide Bay.

Fragment of phragmocone, with test, and complete body chamber with lappet, 11a×1.2; 11b×2; 11c×1.2; 11d×1.9; rubber cast of natural impression. Loc. A 250. U.W. 16658.

12 a, b. **Praestriaptychus** (sub. gen. nov.?) **antiquus** Westermann, sp. nov. 387

Kialagvik formation, *T. teres-profundus* zonule, Wide Bay.

Holotype, enlarged (see Pl. 62, fig. 7); internal mold with test remains, 12a×2.5, whitened; 12b×3.2, natural contrast, showing smooth test, fractured. Loc. A 85. U.W. 16618.

Explanation of Plate 74

Natural size if not otherwise indicated.

Figure		Page
1-3.	**Partschiceras** cf. **P. gardanum** (Vacek)	453

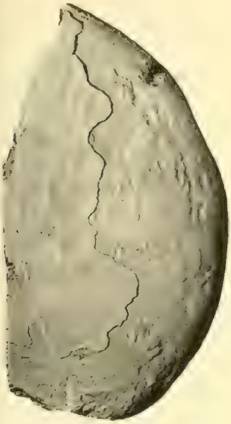
Kialagvik formation, (Middle?) Upper *E. howelli* Zone, Wide Bay.

1 a,b. Fragment of phragmocone, internal mold with test remains. Loc. A 250. U.W. 16659. 2 a,b. Fragment of phragmocone, internal mold, laterally deformed. Loc. L 543. U.W. 16660. 3. Inner whorls, fragmentary, internal mold. Loc. L 543. U.W. 16661.

4-7b.	**Holcophylloceras** cf. **H. ultramontanum** (Zittel)	448

Kialagvik formation, Upper *E. howelli* Zone, Wide Bay.

4. Almost complete internal mold with ½ whorl body chamber, strongly compressed by deformation. Loc. A 10. U.W. 16662. 5 a,b. Fragmentary internal mold of phragmocone, not deformed. Loc. L 543. U.W. 16663. 6 a,b, 7 a,b. Internal molds of almost complete body chambers with ends of phragmocones, somewhat compressed by deformation; some test remains in constrictions. Loc. A 8. U.W. 16664, 16665.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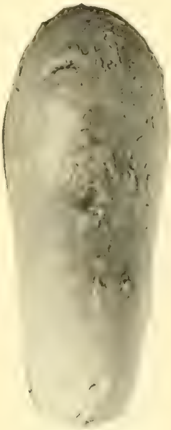
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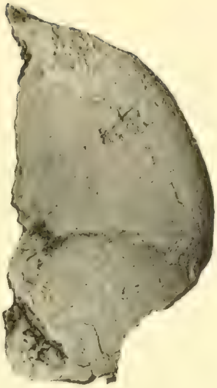
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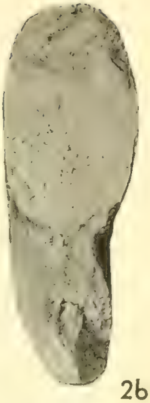
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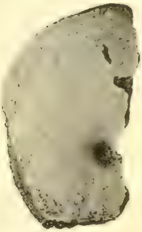
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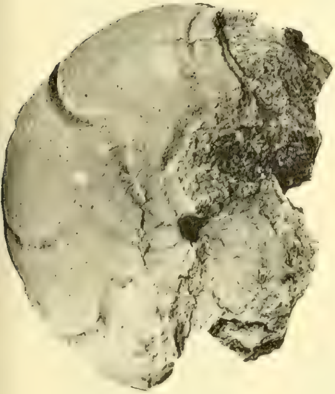
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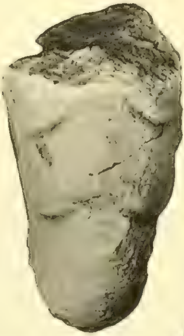
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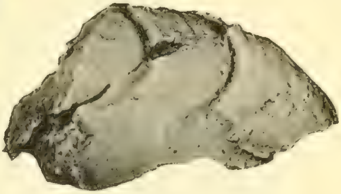
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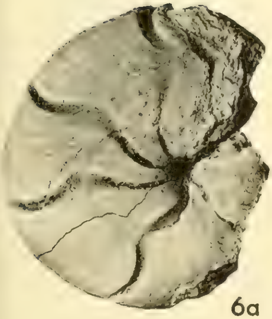
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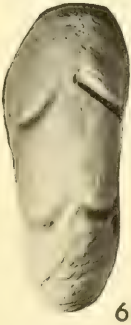
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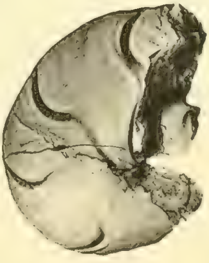
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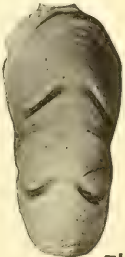
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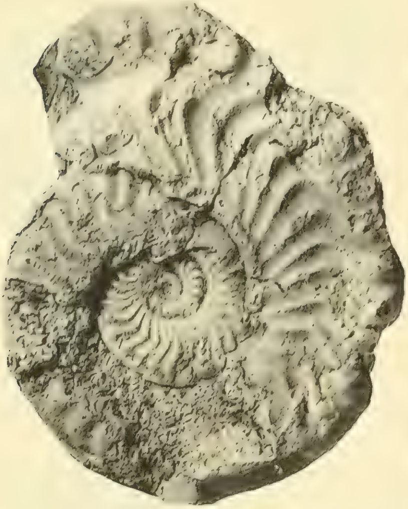
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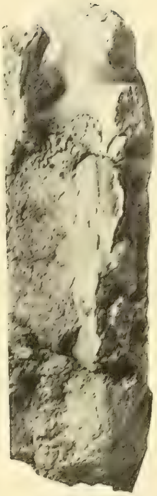
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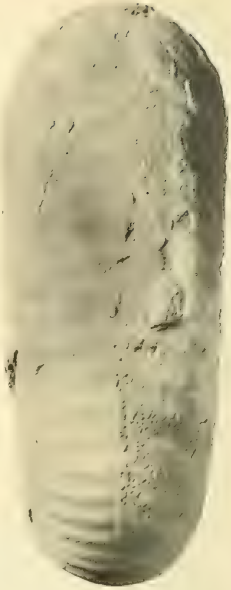
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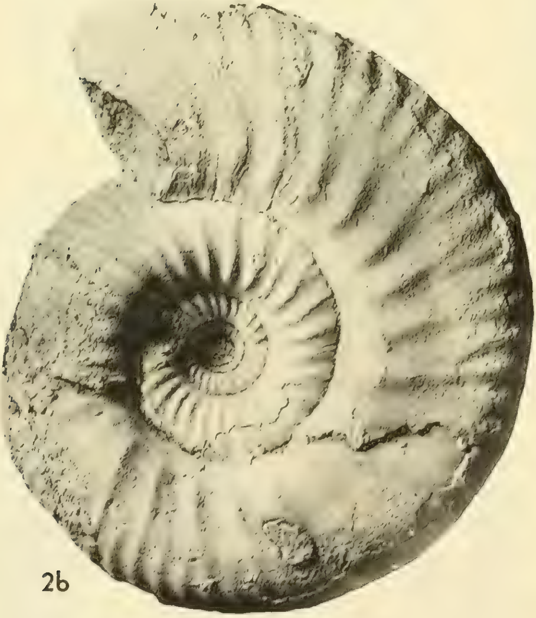
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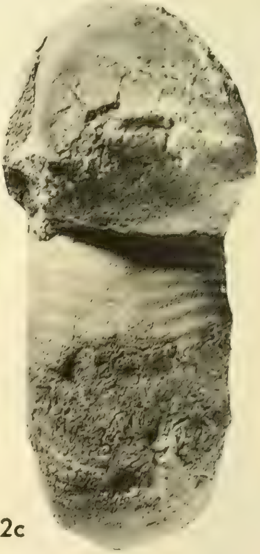

2c

Explanation of Plate 75

Natural size if not otherwise indicated.

Figure		Page
1 a, b.	**Harpoceras (Harpoceras** ?) sp. indet.	450

Incomplete, partly corroded phragmocone, Kialagvik formation, *E. howelli* zonule of *E. howelli* Zone, probably derived, California Academy of Science, Loc. 29016. Wide Bay, Alaska Peninsula.

Figure		Page
2 a-c.	**Erycites imlayi** Westermann, sp. nov.	452

Complete specimen, with test except for first half of body chamber and most if its "venter", end of phragmocone corroded. 2 a. A faint keel is present only on the beginning of the body chamber. 2 c. The costae are subcontinuous on the end of the phragmocone, the "ventral" elements of the septal suture are reduced in size, and the test shows appreciable thickness at the sides of the aperture. Kialagvik formation, *E. howelli* zonule of *E. howelli* Zone, same locality as figure 1. (See Pl. 65).

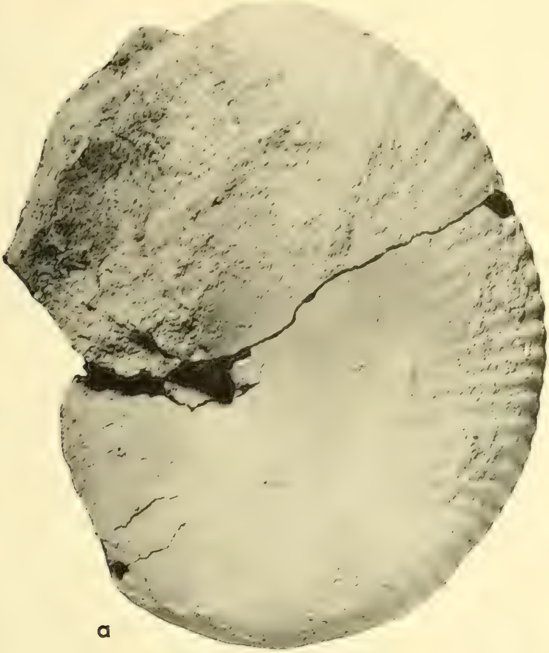
Explanation of Plate 76

Natural size if not otherwise indicated.

Figure Page

Partschiceras gardanum (Vacek), 1886, subsp ? 453

Well-preserved large phragmocone, left side and most of "venter" with test (a,b), right side as internal mold with septal suture (d×1.4); the whorl sections of the ultimate 1 1/2 whorls, filled with calcite, and the nucleus, mostly as internal mold, are visible (c×1.1) after removal of the upper part of the specimens along fracture as shown in (a,b). Kialagvik formation, Middle or lower Upper *E. howelli* Zone, California Academy of Science, Loc. 29017, Wide Bay, Alaska Peninsula. (See Pl. 74.)



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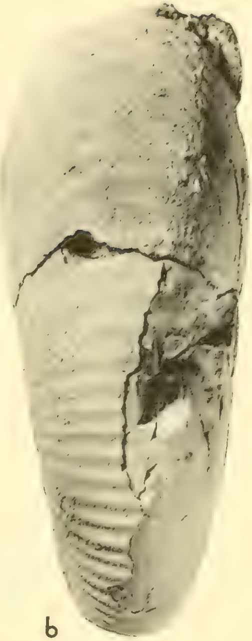

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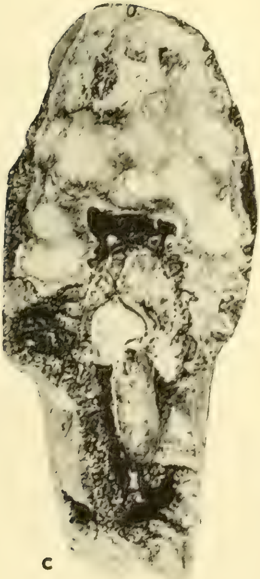

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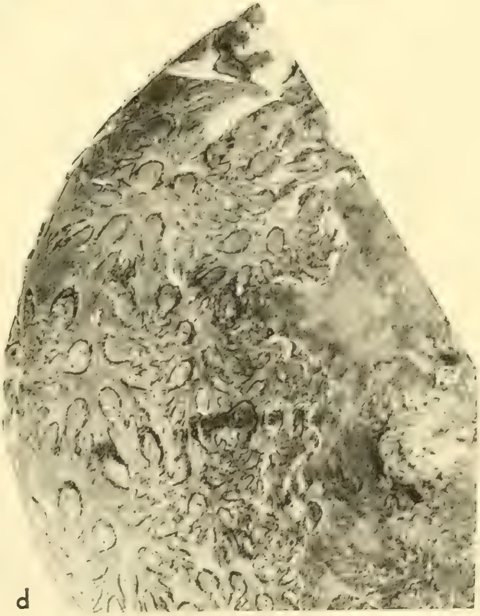

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SOME NEOGENE MOLLUSCA FROM FLORIDA AND THE CAROLINAS

By

AXEL A. OLSSON AND RICHARD E. PETIT

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SOME NEOGENE MOLLUSCA FROM FLORIDA AND THE CAROLINAS

AXEL A. OLSSON[1] AND RICHARD E. PETIT[2]

INTRODUCTION

The purpose of this paper is to describe several new species of Tertiary mollusks and to notice a few others of importance from south Florida and the Carolinas, together with a short account of the Tertiary geology and stratigraphy of south Florida.

The importance of the marine Tertiary succession of south Florida in the solution of many perplexing problems of correlation and age assignment has become more fully evident during late years. Knowledge of the Tertiary stratigraphy of south Florida has grown slowly, hampered by the almost complete lack of reliable surface sections of appreciable thickness. Ideas of age and sequence of beds were, therefore, based almost wholly on random fossil collections, mostly from spoil banks or other loose material and badly mixed, hence conflicting views arose from time to time. Some of these difficulties have been resolved during late years through increased opportunities of direct study of fresh exposures and the collection of fossils in place, afforded by deep excavations laid open during several major construction projects. South Florida offers unexcelled opportunities for research along precise stratigraphic lines through the digging of pits at carefully selected sites under strict geological supervision.

This paper is divided into two sections: the first part by the senior author presents a short account of the Tertiary geology and stratigraphy of south Florida so that the significance of the fossil shells may be better understood as well as to place on record the main results of studies on the succession and interrelationship of the fossiliferous horizons carried on during the past few years; the second part under joint authorship is devoted to the description of several new species and a discussion and illustrations of several others.

ACKNOWLEDGMENTS

We are indebted to a host of friends and co-workers who have donated rare or exceptionally finely preserved specimens or assisted us

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[1] Honorary Research Associate, Smithsonian Institution; Research Associate, Paleontological Research Institution and of the Academy of Natural Sciences of Philadelphia.

[2] Research Associate, Paleontological Research Institution.

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during innumerable field trips. We are especially appreciative of the assistance of Mr. Druid Wilson, Tertiary Paleontologist of the United States Geological Survey, both in the field and at the National Museum in Washington; he was the first to recognize the distinction of the Acline fauna from near Punta Gorda and its late Miocene age, as well as many other significant stratigraphic relations of the fossiliferous beds in south Florida. Special thanks are also due Mr. Charles R. Locklin and Mrs. Edna Marcott, both of St. Petersburg, for much important material, mainly from the St. Petersburg diggings from time to time; also to Mr. Joseph Banks, geologist, who accompanied the senior author on many field excursions, particularly along the Caloosahatchee River, the Miami Canal, and along the northwestern shore of Lake Okeechobee; to Mr. Howard Klein of the Water Resource Division of the United States Geological Survey stationed in Miami; also to several local collectors of Recent and fossil shells in the Miami area, especially to Miss Muriel Hunter, Mrs. Dora McQuery and Mr. and Mrs. G. Williams. For other interesting and special donations of the shells of rare species, the authors are indebted to Mrs. Helen O'Brien of Daytona Beach, and to Mrs. J. W. Donovan of West Palm Beach, Florida.

During the collecting of Waccamaw shells in the Carolinas, a few of which are noticed in this paper, the junior author wishes to acknowledge the splendid assistance received from Messrs. Ray Brennan and Jim Morton, both then stationed at Myrtle Beach Air Force Base, South Carolina, in the field as well as for the donation of several special specimens.

As always, it is a pleasure to acknowledge our great indebtedness to Dr. K. V. W. Palmer, Director of the Paleontological Research Institution and Editor of its publications, for her cooperation in the writing and final printing of this and many other papers.

Holotypes of the new species will be deposited in the U. S. National Museum at Washington, D. C., paratypes and other specimens in the Paleontological Research Institution at Ithaca, New York.

Coral Gables, Florida Axel A. Olsson
January, 1964

Ocean Drive Beach, Richard E. Petit
South Carolina
February, 1964

PART 1. THE GEOLOGY AND STRATIGRAPHY OF SOUTH FLORIDA

Axel A. Olsson

ABSTRACT

The senior author presents a short account of the stratigraphy of the Tertiary rocks of south Florida. These Tertiary rocks seldom outcrop but underlie at shallow depth the whole of south Florida and are dug into at innumerable locations. Four stratigraphic units are recognized, of which one "The Pinecrest beds" is named for the first time. A few of the more characteristic fossil species of each unit are listed and problems of age and correlation are briefly discussed.

INTRODUCTION

The richly fossiliferous beds of south Florida, generally known as "The Caloosahatchee", comprise three or more separate units, distinguishable by their stratigraphic position, faunal content, and often separated by sharp unconformable contacts. These units may occur in such close conjunction that fossil collections made from spoil banks or other loose material along canal embankments and levees are generally mixed, the shells derived from different beds. These units have a wide, although uneven distribution in the shallow subsurface, generally covered by an overburden of Pleistocene or more Recent sands, muck, and peat deposits, their natural outcrops confined to the banks of the Caloosahatchee River and a few other stream courses. Such river bank exposures are scattered, small in extent and thickness, and have been subjected to all the hazards of surface disturbances occasioned by storms, flooding, weathering, slumping, root penetration, and the like while the Pinecrest unit, the most widespread Caloosahatchee horizon, is as yet unknown in any surface outcrop. Although seldom outcropping, the Caloosahatchee shell beds are penetrated in numerous pits dug for fill and ballast as well as in the dredging or deepening of many canals. During the last few years, an entirely new area for the investigation and collecting of Tertiary shells was opened up in Glades and parts of Highland counties along the northwestern shore of Lake Okeechobee during the building of a line of high storm levees extending from Indian Prairie Canal to Fish Eating Creek. The new canal ditch, adjacent to the levee, was dug across firm land, thus exposing fresh formation, unaffected by slump or any other surface disturbance. In most cases, the drag-line operation proved most efficient if carried out under dry or nearly dry conditions, obtained in damming off the older section of the canal, and the new ditch in front kept free of water by continuous pumping. Through this fortunate circumstance, it was possible to enter into the canal ditch, often to a depth of 25 feet or more, to examine directly the exposures in the bank, and at frequent intervals of time, for nearly the whole length of the canal system. Other locations for the examination of fresh exposures and the collecting of fossils in place were made available at deep excavations in preparing sites for the building of large pumping units, such as for Pump Station No. 8 on the Miami Canal. These ditches and excavations were necessarily transitory, the ditch filling to the brim with water as the drag-lines moved forward or to a new location, therefore, frequent observations became imperative. Mr. Thomas Hughes, late of Fort Pierce, Florida, carried on such inspection weekly from the start of this construction project. His untimely death in March, 1962 left much of his work unrecorded, but his large collection of fossil shells was saved and is now housed at the National Museum in Washington. Hughes' interpretation of the basic stratigraphy and the age significance of the fossils arrived at largely independently, is much the same as one proposed here.

Heilprin in 1887, in his discussion of the then newly discovered fossiliferous beds along the Caloosahatchee River, recognized their high position in the Tertiary development, and referred them to the Pliocene. Conforming to an earlier scheme of classification in which he had divided the East Coast Miocene deposits into three general, regional groups (the "Marylandian as oldest, the Virginian, and Carolinian as youngest") Heilprin proposed for the south Florida deposits the name "Floridian" and considered them the highest and youngest marine Tertiary sediments so far discovered along the Atlantic coast seaboard. Heilprin's age assignment of the Caloosahatchee to the Pliocene was accepted by Dall and by most other authors since. A large list of Caloosahatchee mollusks was compiled by Dall in 1906 and is included in the final summation of his great study on Florida fossils, and another by Fargo (in Olsson and Harbison) in 1953. These species lists are now known to be composite since they were based on mixed collections from many localities, derived in a large measure from loose spoil bank material or collected from beds then not properly understood or stratigraphically delimited. Hence, the indicated percentage relationship of the Caloosahatchee marl fauna with the Recent appeared considerably higher than actually is the case. Fossils from the beds between the Tamiami formation and the Caloosahatchee marl proper, named herein "The Pinecrest beds", are in many cases identical or closely related to well-known Miocene species elsewhere. The Miocene character of the Acline fauna, a facies of the Pinecrest, was first demonstrated by Tucker and Wilson (1933), and by Mansfield (1931) for the Pinecrest at about the same time. The mollusks of the Caloosahatchee marl and the Pinecrest beds are so closely related through evolutionary development that such differences shown by a few special species seem relatively insignificant. They are such as would naturally occur in any border or transitional zone between two major faunal provinces controlled by shifting currents and water temperature,—the fauna of the Caloosahatchee marl being decidedly tropical, that of the Pinecrest tropical and temperate in degree according to location. Perhaps the most significant deduction derived at from present data is that contrary to a widely accepted view, the Caloosahatchee fauna is more closely related to that of the Miocene than it is to the Recent or Pleistocene. The recent differentiation of a new stratigraphic unit (Unit A) by Druid Wilson between the Caloosahatchee marl and the Fort Thompson Pleistocene, and separated from both by sharp unconformable contacts, has emphasized this situation still more strongly. The age assignment of the Caloosahatchee to the mid-Pleistocene as recently advanced by Du Bar (1958) is, therefore, wholly incompatible with existing information, and the true position of the Caloosahatchee in the upper Tertiary as held by all earlier workers remains more firmly established than ever. The sharp distinctions which separated the Tertiary molluscan faunas from those of the Recent and Quaternary will be briefly discussed later.

The following chart shows the principal Tertiary units recognized in this paper and their age equivalents in North Florida and the Carolinas. The highest and youngest of these Tertiary units, Unit A, will shortly be named by Druid Wilson and its geology and paleontology fully discussed. Units B and C, the Caloosahatchee marl and the Pinecrest beds, are broadly referred to the "Caloosahatchee Group," the Unit D to the "Tamiami Group." The term "Neogene" is here used in its original sense (Hoernes, 1853, and adopted by Haug, 1920) for the upper half of the Tertiary system (namely Miocene and Pliocene). The extension of the Neogene to include the Quaternary (*The Treatise on Invertebrate Paleontology*) is unacceptable and wholly contrary to its original definition and purpose.

Principal Tertiary Units in South Florida and Their Correlatives.

QUATERNARY	Pleistocene			South Florida Fort Thompson unconformity	North Florida		Carolinas
TERTIARY	NEOGENE (Miocene and Pliocene)	Upper Neogene (Late Miocene and Pliocene)		Unit A unnamed unconformity	Choctawatchee formation		
			Caloosahatchee Group	Unit B Caloosahatchee marl vague contract			Waccamaw
				Unit C Pinecrest beds partial unconformity		Cancellaria zone	Duplin
			Tamiami Group	Unit D Tamiami unconformity		Ecphora zone	Yorktown
						Yoldia zone	

UNIT D. THE TAMIAMI FORMATION

Proposed by W. C. Mansfield in 1909 for a Tertiary deposit encountered in roadside ditches and rock pits in the area near the junction of Route 41 (Tamiami trail) and Route 29 in Collier County, Florida. The formation directly underlies, except for a patchy cover, a large part of the western Everglades, extending northwestward from Sunniland to the Caloosahatchee River and westward to the coast at Punta Gorda and Fort Myers, Lee County. It is exploited as fill and ballast throughout this zone of near surface outcrop, the principal pits being located at Sunniland and at Fort Myers. The formation is made up mostly of calcareous marls with layer of fine quartz sand, the limy beds often consolidated into hard limestones. Fossils are plentiful, mostly molds and casts, except those composed of calcite such as pectens, oysters, barnacles, and echinoids which are preserved intact and generally in good shape. Due to this unsatisfactory condition of most of its fossils, the Tamiami fauna remains imperfectly known and only pectens, oysters, echinoids and barnacles are properly identified. The Tamiami correlates well with the Yorktown formation of North Carolina and Virginia. The Buckingham marl is a light or cream-colored facies of the Tamiami.

The base of the Tamiami is unknown and apparently has not been seen or recognized in any outcrop. Its upper contact with the Pinecrest is believed to be an unconformity in some cases, and in well borings is indicated by the sudden appearance of quantities of barnacle and echinoid fragments in the cuttings as well as phosphatic pebbles and nodules. At other places, there may be a transitional zone between the two units judging by the intermixture of fossils from both horizons seen on many spoil banks.

Principal Tamiami fossils

Echinoids

- *Arbacia crenulata* Kier
- *Lytechinus variegatus plurituberculatus* Kier
- *Clypeaster sunnilandensis* Kier
- *Encope tamiamiensis* Mansfield
- *Encope michelini imperforata* Kier
- *Mellita aclinensis* Kier
- *Rhyncolampas evergladensis* (Mansfield)
- *Echinocardium gothicum* (Ravenel)

Barnacles

- *Balanus concavus chesapeakensis* Pilsbry
- *Balanus concavus glyptopoma* Pilsbry

Brachiopods

- *Discinisca lugubris* (Conrad)

Mollusks

- *Ostrea sculpturata* Conrad
- *Ostrea disparilis* Conrad
- *Ostrea locklini* Gardner
- *Ostrea coxi* Gardner
- *Pycnodonta haitensis* (Sowerby)
- *Spondylus bostrychites* Guppy
- *Pecten* (*Pecten*) *hemicyclicus* Ravenel
- *Aequipecten* (*Plagioctenium*) *evergladensis* Mansfield

Aequipecten (*Plagioctenium*) *tamiamiensis* Mansfield
Lyropecten (*Nodipecten*) *collierensis* Mansfield
Lyropecten (*Lyropecten*) *jeffersonensis* (Say)
Placuanomia burnsi (Mansfield)

UNIT C. THE PINECREST BEDS. NEW NAME.

The name "Pinecrest beds" is herein proposed for certain strata composed largely of sand, barren or highly fossiliferous, encountered directly below a surface limestone in the general region of the 40 mile bend on the Tamiami Trail (Route 41) west of Miami in the western part of Dade County and extending across its boundary into Collier County, Florida. The name is taken from an old settlement on the Everglades road (which branches off from the present highway at 40-mile bend) about one mile west of the Dade-Collier County line. A small collection of fossils taken from ditches or pits in this area was described by Mansfield in 1931, who considered their age as late Miocene. The Acline fauna, first described by Tucker and Wilson (1932, 1933) from a few pits in the Punta Gorda area, belongs to the same stratigraphic unit and is considered as a facies development.

Throughout the Pinecrest region, the surface muck and peat is directly underlain by a massive bed of limestone, so hard that it must be blasted through during the digging of pits and ditches. At most places, the rock is so dense and recrystallized that only indistinct sections of fossils are visible but more rarely, the limestone becomes partly öolitic with interbedded softer layers containing a few recognizable shells such as *Chione cancellata, Thericium* and *Helisoma.* It is considered the equivalent of the Fort Thompson and hence of Pleistocene age. Below this hard surface limestone is a band of soft fine quartz sand, ranging from 10 to 20 feet in thickness. Over a part of this region, this sand bed is barren of fossils aside from scattered worn fragments of *Turritella* and *Macrocallista.* The formation has much the appearance of a beach deposit and worn flat disk-shaped quartz pebbles are plentiful at a few places.

Locally, the Pinecrest beds in the type area may be fossiliferous, carrying predominately a pelecypod assemblage in which *Macrocallista reposta* (Conrad) and *Spisula incrassata* (Conrad) exceed all others in numbers, but several other important species, rare elsewhere, are common here. Most important of the molluscan species found here are: *Cancellaria propevenusta, Olivella gladeensis. Siphocpraea carolinensis floridana, Petaloconchus* sp., *Trivia* sp., *Turbo* sp., *Ecphora* sp., amongst the gastropods; *Anadara* *sellardsi, Trachycardium evergladeense, Carditamera tamiamiensis, and Glycymeris floridana* amongst the Pelecypoda.

In the Punta Gorda region, the distribution of the Pinecrest unit appears to be patchy and is known only from a few pits at Acline where its beds rest on the Tamiami and are overlain by the Caloosahatchee marl. The Acline mollusks have been well collected, and Druid Wilson tentatively estimates its size as about 600 species, making it the richest assemblage known from a single locality and horizon in Florida. One of its most interesting species is *Dorsanum* (?) *plicatile* (Böse), first found in Mexico, also known from a few other places in south Florida and in north Florida.

The Pinecrest beds form the subsurface through a large part of western Broward and Palm Beach counties and its fossils show up abundantly on the levee embankment along Miami Canal. *Mercenaria tridacnoides* is plentiful on a canal in Florida State Indian Reservation east of Miami Canal. Along Miami Canal, both Caloosahatchee and Pinecrest fossils are commonly intermixed, but the Pinecrest forms can be easily recognized by their darker color and adherent matrix. Common amongst the Miami Canal mollusks are *Chionopsis procancellata* and *Cerithioclava dalli.*

The largest known area of the Pinecrest beds in the shallow subsurface extends through parts of Glades, Highland, and Hendry counties north and northwest of Lake Okeechobee. In this district, the Pinecrest beds were dug into along several canals and ditches and at the time of excavation offered unusual opportunities for direct geologic observation and collecting. As its molluscan fauna shows many marked peculiarities of its own, it has been called "The Brighton facies," Brighton being a locality west of the town of Okeechobee which offered exceptional fine collecting possibilities. The Brighton facies has many special species, such as *Malea densicostata, Trochita floridana, Semele harveyensis,* and *Siphocypraea* in many variants. Together with these purely southern types, there is also a high admixture of northern forms, such as *Mulinia congesta, Astarte, Cyclocardia, Ilyanassa,* giving to the whole fauna a decidedly Chesapeake Miocene aspect.

As observed during canal diggings, the Pinecrest beds north of Lake Okeechobee were, at times, directly overlain by Pleistocene or by small patches of Unit A, the contact between them in all cases being a sharp unconformity, stained heavily with iron and along which issued copious flows of water. The upper surface of the Pinecrest beds was generally strongly indurated and often paved with flattened valves of *Glycymeris americana* and other fossils. The contact between the Caloosahatchee marl and the Pinecrest was seen at a place a short distance northeast of Harney Pond, and was marked by an inclined bed filled with small Turritellas, and would have been entirely overlooked if not especially searched for.

PRINCIPAL PINECREST FOSSILS

Coral

Astrhelia sp. (a new species according to J. W. Wells, related to *A. palmata* of the Choptank Miocene). Pinecrest

Mollusks

Anadara cf. *sellardsi* Mansfield Pinecrest
Trachycardium evergladeense Mansfield Pinecrest and Acline
Pycnodonta haitensis (Sowerby) Lowest bed, Pinecrest
Mytilus incrassata Conrad Pinecrest and throughout Brighton facies
Spondylus rotundatus Heilprin Indian Reservation
Mulinia congesta Conrad Brighton facies
Spisula incrassata Conrad Pinecrest
Raeta undulata (Gould) Throughout Brighton facies
Mercenaria tridacnoides Conrad Florida State Indian Reservation
Chione erosa Dall Pinecrest
Chionopsis procancellata Mansfield Miami Canal
Macrocallista reposta (Conrad) Pinecrest
Semele harveyensis Mansfield Throughout Brighton facies
Macoma sp. Brighton facies
Cymatosyrinx aclinica Tucker and Wilson Acline, Pinecrest, Miami Canal, Brighton, Indian Reservation
Trigonostoma carolinense (Emmons) Brighton, Kissiminee
Cancellaria (*Massyla*) *propevenusta* Mansfield Pinecrest, Indian Reservation
Olivella fargoi Olsson and Harbison. Throughout Brighton facies
Olivella gladeensis Mansfield Pinecrest
Olivella tamiamiensis Mansfield Acline, Pinecrest
Dorsanum ? plicatile (Böse) Acline, Miami Canal
Ecphora quadricostata umbilicata (Wagner) Pinecrest, Indian Reservation, Brighton
Malea densicostata Rutsch Indian Prairie
Trochita floridana, new species St. Petersburg, Fish Eating Creek
Turritella pontoni Mansfield Pinecrest
Turritella gladeensis Mansfield Pinecrest, Indian Reservation
Siphocypraea carolinensis floridana Mansfield Acline, Pinecrest
Siphocypraea carolinensis transitoria, new subspecies Brighton

UNIT B. THE CALOOSAHATCHEE MARL

In 1887, and again in 1892, Dall described the fossiliferous deposits along the Caloosahatchee River as the "Caloosahatchee beds" assigned a short time before by Heilprin to the Pliocene. Later, other geologists such as Matson and Clapp (1909) and C. W. Cooke (1929) referred to the same unit by the name "Caloosahatchee marls," the name adopted in this paper.

La Belle on the Caloosahatchee River may be taken as the type location for the Caloosahatchee marls, and its fossiliferous beds outcrop along the banks of the river at several places or are dug into at nearby pits. For a more precise location, the outcrop seen on the south bank of the river about a mile east of La Belle can be selected as type since the place is readily accessible and the marls rich in fossils. Just prior to Heilprin's time, the site of Fort Thompson, a few miles upstream from La Belle, marked the head of navigation on the river, there being a series of small rapids there, above which the waters meandered over flat swamp land covered with saw grass or heavily choked with aquatic vegetation. Along the La Belle stretch, the Caloosahatchee marl lies directly on the Tamiami, as small outcrops of these underlying beds with *Balanus concavus glyptopoma, Disciniscа,* and fish remains occur in close conjunction with the Caloosahatchee at several places. Above, the Caloosahatchee marl is overlain by Unit A, its basal bed being the zone of *Crassostrea virginica labellensis* along a wavy contact or by the Fort Thompson Pleistocene.

At La Belle, the usual development of the Caloosahatchee is a friable shell marl, yellowish on surface exposure, grading to gray or blue within. After drying out, the marl disintegrates and washes easily, leaving behind a residue of small shell fragments and, if carefully selected, a profusion of small or minute shells in perfect condition. Large specimens of *Strombus leidyi, Conus adversarius tryoni, Siphocypraea problematica, Fasciolaria scalarina, Liochlamys bulbosa, Turritella perattenuata, Arca wagneriana, Anadara crassicosta, A. scalarina,* and a host of others are scattered throughout the unit. For students and others interested in molluscan shells, the Caloosahatchee marl at La Belle offers unlimited opportunities for the collecting of fine specimens.

The Caloosahatchee marl appears to be the most restricted of the Tertiary units of south Florida, its principal development lying along a troughlike belt extending from North St. Petersburg in Pinellas County in a southeasterly direction across Manatee, Sarasota, and Hendry counties to the Caloosahatchee River. It is finely exposed in Shell Creek in Hendry County overlain by Unit A. South of the Caloosahatchee River, the formation again lies buried but was encountered all along the Miami Canal dredgings to the northwestern corner of Brower County. In the excavation for Pump Station 8 at the west corner of Palm Beach and Brower counties, the thickness of the marl exceeded 20 feet, the pit still within the unit at the bottom. South of northwestern Brower County, there are no records, and the Tertiary unit may be missing in the Miami area. In an east and northeasterly direction, the Caloosahatchee marl has been encountered in numerous pits near Moore Haven, and in patch-like occurrences in Highland and Glades counties to the northwest of Lake Okeechobee. It was particularly well developed at Harney Pond on Route 68 and during the excavation for levee material at this place afforded unexcelled opportunity for the collecting of finely preserved fossils. In this general area, the Caloosahatchee overlies the Brighton facies of the Pinecrest, the contact between the two units, visible for a short time just north of Harney, was extremely vague and was indicated mainly by a sloping layer filled with small *Turritella perattenuata* and some other typical Caloosahatchee marl species. Further north in Glades County, a few Caloosahatchee marl species are generally encountered along most canal embankments but the unit is believed to be thin and probably patchy throughout this general region.

Caloosahatchee Fauna

Echinoids
- *Lytechinus variegatus plurituberculatus* Kier
- *Echinometra lucunter* (Linné)
- *Encope michelini imperforata* Kier
- *Clypeaster subdepressus* (Gray)
- *Clyeaster rosaceus dalli* (Twitchell)
- *Rhyncolampas ayersi* Kier
- *Agassizia porifera* (Ravenel)

Mollusks
- *Arca* (*Arcoptera*) *wagneriana* Dall
- *Barbatia* (*Calloarca*) *taeniata* Dall
- *Anadara* (*Caloosarca*) *crassicosta* (Heilprin)
- *Aequipecten* (*Plagioctenium*) *solaroides* (Heilprin)
- *Lyropecten* (*Nodipecten*) *caloosaensis* (Dall)
- *Phacoides* (*Armimiltha*) *disciformis* (Heilprin)
- *Miltha* (*Miltha*) *caloosaensis* (Dall)
- *Semele leana* Dall
- *Semele perlamellosa* Heilprin
- *Conus* (*Contraconus*) *adversarius tryoni* Heilprin
- *Turbinella regina* Heilprin
- *Vasum horridum* Heilprin
- *Busycon rapum* (Heilprin)
- *Fusus* (*Heilprinia*) *caloosaensis* Heilprin
- *Fasciolaria scalarina* Heilprin
- *Liochlamys bulbosa* (Heilprin)
- *Solenosteira mengeana* Dall
- *Murex textilis* Gabb
- *Siphocypraea problematica* (Heilprin)
- *Turritella* (*Bactrospira*) *perattenuata* Heilprin
- *Turbo rhectogrammica* Dall

UNIT A. (UNNAMED)

Lying between the Caloosahatchee marl below and the Pleistocene Fort Thompson above, and separated from both by sharp unconformable contacts, generally marked by deep solution channels and waved surface, is a distinct formational and paleontological unit, not yet officially named. A paper naming and describing the geology and paleontology of this newly differentiated formation will be presented shortly by Druid Wilson, hence only a few generalities will be given here. The formation was formerly considered as the upper part of the Caloosahatchee marl with which it is generally closely associated. It is typically a shell marl, composed largely of *Chione cancellata* but including several distinctive species of its own, as well as a few forms such as *Pyrazisinus,* which range upward from the Caloosahatchee marl but become extinct in this unit. The formation is dug into extensively in numerous pits, especially at Belle Glade where, judging by the depth of the pits, it may attain a thickness of 30 feet or more. Contact of the Unit A on the Caloosahatchee marl can be seen at numerous places, especially along the Caloosahatchee River; to the east of La Belle, the base of Unit A is the zone of *Crassostrea virginica labellensis* along an undulating surface. At Ortona Locks, the zone of *Vermicularia erecta* lies a foot or two above the base of this unit; other contacts were observed during the canal digging northwest of Lake Okeechobee, and as previously noted, the beds of Unit A may lie directly on the Pinecrest or on the Caloosahatchee marl, the contact everywhere being sharp; in Shell Creek, Unit A lies on the Caloosahatchee marl, again with a sharp contact and change in faunal content.

A few of the more characteristic species of Unit A

Coral

Arcohelias limonensis Vaughan

Mollusks

Anadara (*Anadara*) *tuberculosa* (G. B. Sowerby, I)
Recent, Panamic-Pacific Province
Anadara (*Caloosarca*) *aequalitas* (Tucker and Wilson)
Noetia (*Eontia*) *platyura* Dall
Glycymeris americana (Defrance)
Eucrassatella speciosa A. Adams
Miltha sp. (large)
Acrosterigma declive (Gabb)
Oliva, new species
Fusus watermani M. Smith
Fasciolaria okeechobensis Tucker and Wilson
Fasciolaria apicina Dall subspecies

Melongena bispinosa Philippi
Vasum floridanum McGinty
Strombus mayacensis Tucker and Wilson

AGE OF THE CALOOSAHATCHEE GROUP

As noted earlier in this paper, the molluscan list of the Caloosahatchee compiled by Dall and the later one by Fargo indicated a high percentage of species still living. Most conspicuous amongst these Recent species is *Chione cancellata,* a common lagoonal form whose abundance increases progressively from a relatively few in the Pinecrest to large numbers in Unit A, and it is this occurrence which gives the Caloosahatchee faunal assemblage its most modern aspect. The separation of Unit A from the Caloosahatchee proper, as a distinct formational and paleontological unit, has substantially lowered its percentage relationship with the Recent. The Caloosahatchee mollusks also contain a large number of special species and genera which have no counterpart in the Recent, and it was largely because of this endemic element that Heilprin, Dall, and most other authors referred these Florida deposits to the Pliocene. The more recent elaboration of the rich Pinecrest fauna in its many facies, has greatly modified the conception as to the real nature and affinities of the Caloosahatchee fauna as a whole, and shows that the fauna is much more closely related to the Miocene than previously supposed. Most of these special species and genera became extinct at the end of Caloosahatchee marl time and only a few lingered on into the overlying Unit A.

In the total number of molluscan species, the Pinecrest is much richer than the Caloosahatchee marl, explainable because of its wider regional distribution and more varied facies development, its full makeup including elements of northern origin (*Ecphora, Ilyanassa, Cyclocardia, Astarte, Mytilus*) together with southern ones (*Malea, Trochita, Siphocypraea,* and numerous ornate Turritellas). A significant feature of both the Pinecrest and Caloosahatchee mollusks is the number of genera and species groups now living along the Pacific Coast of tropical America, absent from the West Atlantic-Caribbean region, some of which are so close to the living Pacific form as to warrant the use of the same specific name (*Raeta undulata* Gould, *Anadara tuberculosa* (Sowerby) in Unit A) while the number of so-called Pacific genera or groups of closely similar species (*Trochita, Malea, Perplicaria,* ornate Semeles) in the Caloosahatchee is considerable. This aspect of the Caloosahatchee molluscan fauna has not been sufficiently emphasized in the past, but it shows how nearly related the south Florida deposits are to those of the Miocene of the West Indies and Caribbean region. It also points up the sharp distinction which exists between the Tertiary molluscan faunas and those of the Pleistocene and Recent.

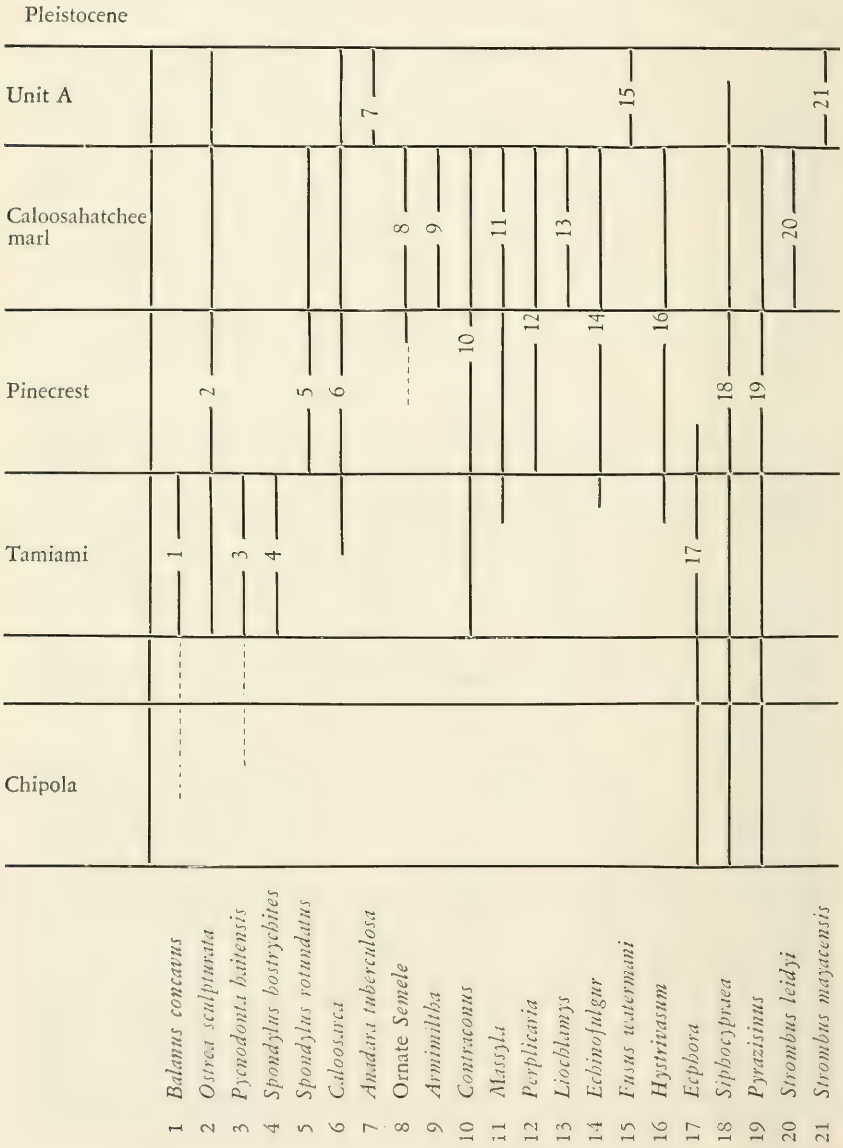
The correlation of the Pinecrest beds with the *Cancellaria* zone of Choctawatchee of northern Florida and with the Duplin Miocene in the Carolinas has been mentioned, hence an age assignment of the Pinecrest to the late Miocene is indicated. The Pinecrest beds and the Caloosahatchee marl were formed during the same depositional cycle and marine invasion and their molluscan faunas are related through direct evolutionary development, hence it is obvious that their geologic ages cannot differ too greatly. In this paper, these two units are referred to the upper Neogene, used as indicated in the chart for the combined late Miocene and Pliocene time.

GENERAL SUMMARY

The following chart presents in a graphic manner the ranges of a few common Tamiami and Caloosahatchee genera and groups of characteristic species. The lower range limits of most of these genera and species groups are still imperfectly known, but a few, such as *Ecphora, Siphocypraea,* and *Pyrazisinus,* occur in the Tampa or in beds of early Miocene age. The upper range limit of most of these genera and species groups terminate sharply in the Caloosahatchee marl, only a few continue across the line into Unit A. There is, therefore, a much greater faunal break between the Caloosahatchee and Unit A than there is between Unit A and the Pleistocene.

The marine Pleistocene mollusks of south Florida have not been fully tabulated, but it is generally known that the fauna is small, probably not exceeding 200 species at any single station, a fraction only of the rich, diversified assemblages know from the Pinecrest and Caloosahatchee beds in the same general area. This great difference between the Pleistocene and Tertiary faunas appears to hold true throughout the whole West Indian-Caribbean region and is the result of a major extinction due to sea-level changes which occurred at the end of the Tertiary or in early Pleistocene time. It is obvious that any general lowering of sea level over a large region would have a drastic effect on the shallow-water or platform marine life, the kind of fossil remains most commonly encountered in a Tertiary or Pleistocene deposit. This extinction was contemporaneous with impor-

Chart showing the range of a few Tamiami and Caloosahatchee genera and species groups



tant geologic changes, especially in the southern Caribbean, of which the most obvious visible result was the uplift of the isthmian land bridge connecting North America and South America and the final closing of several major interoceanic straits or waterways which since early Tertiary times had served as migration routes for marine animal and plant life between the Atlantic and Pacific. The extinction of marine life at the end of the Tertiary was greatest on the Atlantic side, hence the Caribbean-West Indian molluscan fauna is meager and depauperate in number of genera and species as compared to that of the rich Panamic-Pacific one. This great contrast between the West Atlantic Tertiary and Quaternary molluscan faunas is important since it affords a means of recognizing a Pleistocene assemblage by the absence of several extinct genera and groups of species as well as drawing a sharp line of separation between the Tertiary and Quaternary marine deposits.

A few general conclusions can therefore be made:

1. The Tamiami and the Caloosahatchee groups belong to the Upper Neogene (whether to the late Miocene or Pliocene is relatively unimportant).
2. The Pinecrest beds and the Caloosahatchee marl were deposited during a single marine invasion or transgression which swept across the whole of south Florida as well as northward to the Carolinas. It was probably a part of a still greater Miocene transgression which included that of the "Murfreesboro"-Yorktown and possibly also that of the Gatun transgression of the Caribbean.
3. The Caloosahatchee marl and the Waccamaw beds of the Carolinas are contemporaneous deposits and were laid down during the closing or recessive phase of this late Neogene transgression, hence the Caloosahatchee marl has the smallest areal distribution, and being partly or wholly cut-off from the Atlantic, its fauna is also the most tropical.
4. The deposits of Unit A were formed during a later, major, marine transgression which covered a large part of southern Florida. The unit carries a distinctive series of molluscan fossils, including a few hang-overs from the Caloosahatchee. The occurrence of *Anadara tuberculosa* (Sowerby), a mangrove-mud species, now living in the Panamic-Pacific region, is of special interest. The unit is referred to the late Pliocene, but an early Pleistocene age is also possible.

5. Marine mollusks, mainly derived from the Pinecrest beds and the bones and teeth of land vertebrates occur together along many canal embankments, the vertebrate remains often in some abundance These places offer the prospect of determining the actual mode of occurrence of the vertebrate fossils in relation to the marines through the digging of a series of pits under close geologic supervision.

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Part 2. PALEONTOLOGY AND SYSTEMATIC TREATMENT

AXEL A. OLSSON AND RICHARD E. PETIT

ABSTRACT

Part 2 by both authors deals with the description of 20 new species and three new subspecies of Tertiary mollusks from south Florida and the Carolinas along with discussions of several others. Two new subgenera are proposed, namely:—

Emmonsella, as a subgenus of *Trigonostoma,* type, *T. tenerum* (Philippi).

Hystrivasum, as a subgenus of *Vasum,* type, *V. horridum* Heilprin.

SYSTEMATIC DESCRIPTION

Phylum MOLLUSCA

Class PELECYPODA

Family **ARCIDAE**

Genus **ANADARA** Gray, 1847

Type species by original designation, *Arca antiquata* Linné [*Arca scapha* Meuschen (=*maculosa* Reeve)]. Recent, Red Sea.

Subgenus **CALOOSARCA** Olsson, 1961

Type species by original designation, *Anadara rustica* (Tuomey and Holmes)

Anadara (Caloosarca) rustica (Tuomey and Holmes) Pl. 77, figs. 4-4b

Arca rustica Tuomey and Holmes, 1857, Pleiocene Fossils of South Carolina, p. 39, pl. 15, fig. 1

Cf. *Anadara* (*Anadara*) *rustica* Olsson and Harbison, 1953, Acad. Nat. Sci. Philadelphia, Mon. No. 8, p. 37, pl. 3, figs. 1, 1a, and other authors dealing with the Caloosahatchee species [*Anadara crassicosta* (Heilprin), 1887.]

The shell becomes large and heavy at maturity, the umbones and beaks near the anterior one-fourth, the posterior side showing a tendency to become winged and is often deeply sinuated especially in the juvenile stage, while the umbones become more or less deeply sulcated along the middle. The ribs number about 18 from the anterior side to the umbonal angle, and about six or more on the posterior slope, the anterior and middle ones are large, high, and coarsely noded, as narrow as their interspaces, except those along the umbonal slope which are somewhat larger; the posterior set becomes progessively smaller towards the margin. In small specimens, the cardinal area is narrow behind the beaks and bears a few ligamental lines, the space anterior and under the beaks bare. In the larger gerontic specimens, the cardinal area may become high and covered completely with ligamental lines, only a small space under the inrolled, prosogyrate beaks remaining bare. The ventral margin is deeply fluted by the ends of the external ribs. A large specimen measures: length 74.6 mm., height 60 mm., diameter 31 mm., a right valve; another specimen, a left valve, measures: length 83.3 mm., height 55 mm., diameter 29.5 mm.

The original figure of *Arca rustica* given by Tuomey and Holmes was based on a fragment and shows only a section of the anterior side and offers no character separating the Carolina shell from the common *Caloosarca* found in Florida, hence the Caloosahatchee shell came to be known generally as *A. rustica* instead of *A. crassicosta,* the name which Heilprin gave to it with some uncertainty. The discovery of perfect specimens in the Waccamaw beds in South Carolina shows the Carolina and Florida shells to be distinct.

Waccamaw formation: Crescent Beach Airport, Horry County, South Carolina.

Subgenus **LARKINIA** Reinhart, 1935

Type species by original designation, *Anadara larkini* (Nelson). Late Miocene-Pliocene (Tumbez beds) of northern Peru.

Anadara (Larkinia) sellardsi (Mansfield) Pl. 78, figs. 2, 2a
Arca (*Anadara*) *sellardsi* Mansfield, 1932, Florida State Geol. Sur., Bull., No. 8, p. 48, pl. 7, figs. 8, 9.

A large ark, identified as *A. sellardsi* described by Mansfield from the *Cancellaria* zone, Harney Creek, Leon County, in north Florida, has been found in the Pinecrest beds along the canal, near 40 mile bend west of Miami. The holotype and only specimen from north Florida is poorly preserved, lacks surface detail, and is of somewhat different shape, but the identification nevertheless seems fairly certain. Both the Harney Creek and the Pinecrest specimens have a ridge on the hinge side of the umbonal cavity. Specimens from Pinecrest are generally large, thick-shelled, usually obliquely ovate, highest across the posterior zone, the posterior end somewhat extended with a rounded margin. Surface riblets are numerous, narrow between flat interspaces, evenly and finely noded on the anterior slope of both valves, elsewhere the tops of the ribs are plain or merely wrinkled by the growth lines. The beaks are widely separated by a high cardinal area covered by close ligamental grooves forming an inset pattern of low triangles, the hinge line high with a continuous line of vertical teeth. The adductor scars are subequal, deeply inset, probably due to secondary leaching. Pallial line mildly sinuous, fairly close to the margin, and above the marginal flutes.

Family **LIMIDAE**

Genus **LIMA** Bruguière, 1797

Type species by tautonomy, *Ostrea lima* Linné

Subgenus **PROMANTELLUM** Iredale, 1939

Type species by original designation, *Promantellum parafragilis* Iredale. Recent, Australia.

Lima (Promantellum) florpacifica, new species Pl. 77, figs 7, 7a

The shell is obliquely oblong, higher than long, fan-shaped with an appressed flared-out section in the middle of the anterior margin, the posterior margin straight, descending evenly to the widely rounded ventral side, the texture thin, and of a white color. The gap on the anterior side is large; smaller and perhaps absent on the posterior. Surface is sculptured with small, raised, radial ridges, absent or nearly so on the sides.

Height 27.2 mm., length 17.2 mm. Holotype, USNM.

This *Lima* resembles *L. pacifica* d'Orbigny, a living species of the Panamic-Pacific region but differs by its shape, less widely expanded ventrally, and has a wider, more flaring anterior side. The posterior margin of the valve appears straight and may have been completely closed, without a noticeable gap. The shape of our shell is more similar to that of *L. fragilis* Lamarck (as figured in Sowerby, G. B., II. Thesaurus, vol. 1, *Lima,* pl. 22, fig. 37), a Philippine species.

St. Petersburg fossil bed.

Family **ANOMIDAE**

Genus **PODODESMUS** Philippi, 1837

Type species by monotypy, *P. decipiens* Philippi (=*Placuanomia rudis* Broderip). Recent, West Atlantic and the Caribbean.

The shell is irregularly subcircular, attached by its right valve to the substrate, usually by its whole surface. The interior of the right valve has a single crural process which arises as a ridge along the posterior side of the central chalky area and at the dorsal margin becomes enlarged into a prominent knob, its dorsal face folded or bilobate in shape and carrying the attachment scar of the ligament; in the left valve, the resilifer is a wide socket-like cavity cutting deeply into the dorsal margin. The byssal foramen is placed with the central white area well below the dorsal margin, the byssal plug generally retained and is distinguished by its finely lined, vertical structure. There is an elongated adductor scar below the byssal foramen and its plug is also in the central white area. In the left valve, the central white area extends into the resilifer and bears two scars; the upper scar, radially marked, represents the byssal adductor; the lower one smooth or wrinkled, that of the adductor muscle. Exterior of the shell in living specimens is usually brownish with a sculpture of fine radial threads or riblets.

Pododesmus has been considered as a subgenus of both *Anomia* and *Placuanomia*. It appears closest to *Placuanomia* in that the byssal plug is generally retained in the foramen, its face showing as a circular scar well below the dorsal margin and easily recognized by its vertical lining. *Pododesmus* differs from *Placuanomia* by its less strongly plicated surface and in having only a single crural element while there are two separate ones in *Placuanomia* and so placed on the dorsal margin that they resemble large hinge teeth.

Pododesmus waccamawensis (Gardner) Pl. 77, figs. 2-2c

Ostrea waccamawensis Gardner, 1943, U. S. Geol. Sur., Prof. Paper, No. 199-A, p. 41, pl. 3, fig. 17.

Shell of medium size, solid, externally like an oyster. Lower or right valve subcircular to subovate, flat or warped by the close attachment of the larger part of its surface, usually sculptureless or covered with adhering rock matrix. Inside surface of the right valve shows a large crural arm, the upper surface usually bilobate in shape forming the resilifer; below the resiliferal knob is a circular area, generally white and chalky which carries the large circular to subovate foramen, enclosing the byssal plug a little above the middle, while the adductor muscle scar is placed a little below and behind the byssal plug. The upper or left valve shows a large socket-like resilifer cutting deep across the cardinal margin and grades below into the central white area bearing the scar of the byssal adductor and of the muscle adductor. Outer marginal area of the inside of either valve is usually gray or lead covered. The surface of the upper valve if well preserved is sculptured with a series of small, close-set, scabrous riblets.

Height 54 mm., diameter 55 mm., a specimen of the right valve.

The holotype specimen in the National Museum is a poorly preserved lower valve showing a surface sculpture of small riblets and a small section of the byssal plug. The interior of the valve is heavily encrusted with matrix and several small oyster shells are attached to its margin.

Waccamaw formation: Crescent Beach Airport, Horry County, South Carolina.

Family **OSTREIDAE**

Genus **PYCNODONTA** Fischer de Waldheim, 1835

Type species by original designation, *P. radiata* Fischer de Waldheim. Cretaceous, Crimea.

Pycnodonta haitensis (Sowerby) Pl. 78, figs. 7, 7a

Ostrea haitensis Sowerby, G. B., I, 1850, Quart. Jour. Geol. Soc. London, vol. 6, p. 53. Miocene. Santo Domingo.
Ostrea meridionalis Heilprin, 1887, Wagner Free Inst. Sci., Trans. vol. 1, p. 100, pl. 14, figs. 35, 35a.
Ostrea (*Alectryonia*) *meridionalis* Herilprin, Olsson and Harbison, 1953, Acad. Nat. Sci. Philadelphia, Mon. No. 8, p. 51, pl. 4, figs. 3, 3a.
Ostrea tamiamiensis Mansfield, 1932, U. S. Geol. Sur., Prof. Paper, No. 170-D, p. 46, pl. 14, figs. 1, 3.
Ostrea tamiamiensis monroensis Mansfield, 1932, *idem,* p. 46, pl. 15, figs. 1-4.

The common large oyster in the Tamiami ranging up into the lower Pinecrest in some localities. Large specimens are variable in shape, massive, and heavy, the half-grown shells being most typical in shape, both valves showing strong nodosely plicated sculpture. In the interior, the wide marginal band if weathered slightly will show the minutely cellular structure characteristic of the genus.

Tamiami formation: at nearly all stations. Pinecrest: Pinecrest, Miami Canal, Florida.

Family **VENERIDAE**

Subfamily **VENERINAE**

Genus **NIOCHE** Hertlein and Strong, 1948

Type species by original designation, *Venus asperrima* G. B. Sowerby, I., (1835). Recent, Panamic-Pacific Province.

Nioche marcottae, new species Pl. 77, figs. 6, 6a

The shell is small, rounded, and convex with the beak near the anterior one-third. The escutcheon is a flat, smooth area (except for growth incrementals) and seems equally well developed in both valves. The lunule is large, not depressed, defined by an incised line and sculptured with strong riblets and concentrics. External sculpture is finely cancellate, produced by numerous, small, closely spaced lamellae, the alternate ones on both ends enlarged into higher folios, the interspaces and the ventral face of each lamellae cut into by small evenly spaced incised lines, best shown in the mid-zone of the disk, somewhat irregular on the sides. Interior deep, the adductor scars subequal in size, the pallial line placed well within from the margin, the pallial sinus well defined. Ventral margin is finely crenulated.

Length 28.1 mm., height 24.4 mm., diameter of right valve 8.9 mm. Holotype, St. Petersburg.

The generic placement of this species is tentative. It agrees well in its hinge and surface sculpture with *Nioche* but has a flat escutcheon in each valve.

This neatly sculptured species is named for Mrs. Edna Marcott of St. Petersburg, Florida, who collected the first specimens of this interesting species, and to whom we owe the discovery of many other new forms.

St. Petersburg fossil bed.

Genus **PERIGLYPTA** Jukes-Brown. 1914

Type species by original designation, *Venus puerpera* Linné.

Periglypta tamiamensis, new species Pl. 78, figs. 1, 1a

Shell often large, rounded, with convex, equal valves, sculptured with numerous, large, narrow to coarse, concentric riblets, their dorsal sides generally a little reflexed, their summits finely or coarsely noded by radials which show as evenly spaced riblets in the interspaces, especially over the umbonal and mid-surface areas. On the type specimen, there are 70 plus concentric ridges, their wide flat intervals measuring 2 to 3 mm. on the surface a little above the middle.

Length 110 mm., height 112 mm., diameter 35 mm. Impression of a right valve. Holotype, USNM.

This clam is common in the Tamiami limestone at Sunniland, in the form of large molds and impressions, the original shell having been leached away, large specimens often attaining a length of six inches or more. Its generic reference to *Periglypta* rather than to *Ventricola* is indicated by the coarsely corrugated character of its concentric riblets.

Tamiami formation: Sunniland, Collier County, south Florida.

Family **MACTRIDAE**

Subfamily **MACTRINAE**

Genus **MULINIA** Gray, 1837

Type species by subsequent designation, Hermannsen, 1847, *Mulinia lateralis* (Say).

Mulinia congesta (Conrad) Pl. 78, fig. 6

Mactra congesta Conrad, 1833, Amer. Jour. Sci., 1st ser., vol. 23, p. 340.

Mulinia congesta (Conrad), Gardner, 1943, U. S. Geol. Sur., Prof. Paper, No. 199-A, pp. 113, 114, pl. 23, figs. 12-15, 21-24.

Common throughout the Brighton facies of the Pinecrest.

Subfamily **PTEROPSIDINAE**

Genus **RAETA** Gray, 1853

Type species by monotypy, *R. campechensis* Gray [=*plicatella* (Lamarck),=*R. canaliculata* (Say)].

Raeta undulata (Gould) Pl. 78, figs. 5, 5a

Lutraria undulata Gould, 1851, Boston Soc. Nat. History, Proc., vol. 4, p. 89, Gould, 1853, *op. cit.*, vol. 6, pp. 391, 392, pl. 15, fig. 7. Recent, Gulf of California.

Labiosa (*Raeta*) *gibbosa* Gabb, 1870, Amer. Jour. Conchology, vol. 5, p. 30, Gabb, 1874, Acad. Nat Sci. Philadelphia, Jour., vol. 8, p. 264, pl. 35, figs. 8, 8a. Pleistocene ? Peru; Anderson, 1929, California Acad. Science, Proc., 4th series, vol. 18, p. 177. Miocene of Colombia.

Labiosa (*Raeta*) *gabbi* Pilsbry and Johnson, 1917, Acad. Nat. Sci. Philadelphia, Proc., vol. 69, p. 202. Renaming of *R. canaliculata* Gabb, 1873, not of Say, 1821. Miocene of Santo Domingo; Pilsbry, 1921, *op. cit.*, vol. 73, p. 427, pl. 46, fig. 1; Spieker, 1922, John Hopkins University, Studies in Geology, No. 3, p. 266. Miocene of Peru.

Labiosa (*Raeta*) *gardnerae* Spieker, 1922, John Hopkins University, Studies in Geology, No. 3, p. 168, pl. 10, fig. 10. Miocene of Peru.

Labioa (*Raeta*) *hasletti* Anderson, 1929, California Acad. Sciences, Proc., 4th series, vol. 18, p. 177, pl. 23, figs. 2, 3. Miocene of Colombia.

Labiosa undulata gardnerae Spieker, Hodson, 1931, Bull. Amer. Paleont., vol. 16, No. 59, p. 21, pl. 7, fig. 5.

Labiosa (*Raeta*) *undulata undulata* (Gould), Olsson, 1932, Bull. Amer. Paleont., vol. 19, No. 68, p. 131, pl. 14, fig. 11. Miocene of Peru; Hodson, 1931, Bull. Amer. Paleont., vol. 16, No. 59, p. 21, pl. 7, fig. 6. Miocene of Venezuela.

Anatina (*Raeta*) *undulata* (Gould), Keen, 1953, Sea Shells of Tropical West America, p. 159, fig. 364.

Raeta undulata (Gould), Olsson, 1961, Panamic-Pacific Pelecypoda, p. 332, pl. 56, figs. 6-6b.

The lengthy synonymy above, not wholly complete, illustrates the many names which have been given to this widely distributed species in time and space. In the Recent fauna, the species is confined to the eastern Pacific ranging from the Gulf of California southward to Peru, its southern limit not known. As a Miocene fossil, it was distributed throughout the Caribbean region and in the Pacific zone to Ecuador and Peru. It is herein recorded from the Florida beds for the first time. Although variable, *R. undulata* is consistently distinguished from *R. plicatella* (Lamarck) [*R. canaliculata* (Say)], the West Atlantic species, by its larger heavier shell and by its wider fuller umbones and more centrally placed beaks. The Florida fossils match in every respect Recent shells from the coast of Peru.

Pinecrest formation: (Brighton facies) levee along Fish Eating Creek and other places northwest of Lake Okeechobee, Florida.

Family **TELLINIDAE**

Subfamily **MACOMINAE**

Genus **CYMATOICA** Dall, 1889

Type species by subsequent designation. Dall, 1900. *Tellina undulata* Hanley (=*occidentalis* Dall). Recent, Panamic-Pacific Province.

Dall, in 1889, described *Cymatoica* as a subgenus of *Macoma* but without mention of a type; it was followed by the description of two species, *C. occidentalis* and *C. orientalis,* considered as new. In 1900, Dall gave *Tellina undulata* Hanley, a Panamic-Pacific species as type and of which he cited *C. occidentalis* as a synonym.

Cymatioca marcottae, new species Pl. 77, fig. 5

The shell is small or medium-sized, thin, elongate, the umbones depressed, the beaks pointed and placed near the posterior third, the anterior side hence longer. The posterior side has its dorsal margin nearly straight, slopes downward to the end which is narrowly truncated and twisted. The anterior margin is widely rounded and below it curves smooth into that of the ventral margin. The surface is neatly marked with narrow undulations, concentric in the middle of the disk but cutting across the lines of growth as they approach the dorsal margin; on the ventral half of the surface on the type specimen, the undulations take on a concentric-waved form.

Fragments show that this species sometimes reached a length of 15 mm. or more. From the West Atlantic *C. orientalis* Dall, the fossil differs by its longer form and more elaborate surface sculpture.

St. Petersburg fossil bed.

Holotype, USNM 644639. Length 10 mm.

Family **SEMELIDAE**

Genus **SEMELE** Schumacher, 1817

Type species by monotypy, *Tellina reticulata* Spengler (=*Tellina proficua* Pulteney). Recent. West Altantic.

Semele harveyensis Mansfield Pl. 78, figs. 4, 4a

Semele proficua harveyensis Mansfield, 1932, Florida State Geol. Sur., Bull. No. 8, p. 146, pl. 31, figs. 1, 10. *Cancellaria* zone, Harveys Creek, Leon County, Florida.

Shell of medium or large size, ovate to subcircular, both valves of slight convexity, the left a little more than the right. Umbones are nearly medial, its surface somewhat flattened, terminating in small, obliquely set prosogyrate beaks. There is a strong posterior umbonal flexure in each valve forming a fold in the right and a corresponding furrow in the left. The lunule is small and deeply sunken, A narrow flat escutcheon is present in both valves, marked off by an angled margin. The external surface on casual inspection may appear smooth but more closely examined will show minute, streaky radial lines as if produced by a bristly brush; on the anterior submargin and more so on the posterior, these fine radials fan-out laterally and become coarsely granulose. The pallial sinus is deep and wide, broadly rounded at the end, and extends a little past the center.

An average specimen measures: length 56.7 mm., height 51.5 mm., diameter 20.4 mm., Harney Pond Canal, 9½ miles north of road junction of Route 78 and Route 721.

Although Mansfield considered *S. harveyensis* as a subspecies of *S. proficua* Pulteney, a living Florida species, it is more closely related to *S. flavescens* Gould of the Panamic-Pacific Province differing mainly from that species by its generally larger size and somewhat flatter valves. It is a common and characteristic species of the Brighton facies of the Pinecrest beds.

Pinecrest beds: throughout Glades County; also at St. Petersburg.

Family **HIATELLIDAE** (Saxicavidae)

Genus **PANOPEA** Menard de la Groye, 1807

Type species, *P. aldrovandi* Menard de la Groye. Recent, Mediterranean.

Panopea dockensis, new species Pl. 77, figs. 3, 3a

Shell large, moderately thick, ovate, the anterior side short, obliquely rounded, the posterior side longer, curved, becoming somewhat narrowed at the end. Umbones are wide and full, the beaks placed near the anterior end. Interior of the valve shows a deep pallial line and a narrow pallial sinus (the exact shape shown in the figure). Surface white or cream-colored, covered with smoothish, irregularly concentric wrinkles and undulations.

Length 158 mm., height 89 mm.

Distinguished from *P. reflexa* Say and other congenera by its curved, elongated shape, and the strongly anterior position of the beaks and umbones.

Waccamaw formation: Old Dock, on State Highway 130 about 2 mi. N. of Old Dock, Columbus Co., North Carolina.

Holotype, USNM 644638.

Superfamily **PHOLADACEA**

Family **PHOLADIDAE**

Subfamily **PHOLADINAE**

Genus **PHOLAS** Linné, 1758

Type species by subsequent designation, Children, 1822, *Pholas dactylus* Linné. Recent, east Atlantic and the Mediterranean.

Shell elongate, oblong, thin, white, its surface sculptured with concentric ridges and serrated radial riblets. The umbonal reflections or inrolled layers, two in number, are separated by a septate space. Accessory plates are three in number but generally lost in fossil specimens. An internal spoon-shaped process or apophysis is present in the umbonal cavity of each valve.

Pholas (Pholas) memmingeri Tuomey and Holmes Pl. 78, figs. 3, 3a

Pholas Memmingeri Tuomey and Holmes, 1858, Pleiocene Foss. South Carolina, p. 104, pl. 24, fig. 6. Sumter District, South Carolina; Dall, 1898, Wagner Free Inst. Sciences, Trans., vol. 3, pt. 4, p. 815.

The shell is white, of medium weight, subrectangular, the dorsal and ventral sides straight and parallel, mildly rounded to subtruncated posteriorly, more narrowly rounded anteriorly but not beaked. The umbonal reflection is heavy, in two layers, the lower one more solid, heaviest just in front of the beak and separated from the upper layer by a line of small septae. The accessory plates are unknown. The surface is sculptured weakly with relatively few (seven or eight) radial riblets on the anterior side followed by a wide, smooth space and again by a series of weak radials (about five) in the band just behind the middle. The posterior surface is smooth except for a series of large irregular concentrics. The internal apophysis is large, spoon-shaped, crudely indented on the posterior side. The pallial sinus is large and high, connected with the posterior adductor scar just under the margin.

Length 88.7 mm.; height 38.3 mm., diameter of the left valve 17.2 mm. Collection, Miss Muriel Hunter.

This species is referred to the typical section of *Pholas* in that the umbonal reflection is formed of two layers, separated by a septate space and is not affixed solidly to the umbo of the shell. Texture of the single valve is solid so that the pallial line and its sinus are deeply impressed.

The original of this interesting species came from South Carolina and as figured by Tuomey and Holmes represented a poorly preserved fractured specimen. The discovery of this rare shell in Florida is, therefore, an event of importance. A few other fragments, mostly of the umbonal section, are known.

Pinecrest formation: levee along the west side of Fish Eating Creek about half a mile above the bridge along Route 78, Florida.

Class GASTROPODA

Order TOXOGLOSSA

Family **TURRIDAE**

Genus **CYMATOSYRINX** Dall, 1889

Type species by original designation, *Pleurotoma lunata* Lea. Miocene, Yorktown formation.

Cymatosyrinx aclinica Tucker and Wilson Pl. 82, figs. 5-5b

Cymatosyrinx lunata aclinica Tucker and Wilson, 1933, Bull. Amer. Paleont., vol. 18, No. 66, p. 75, pl. 13, figs. 6, 7. Acline, Florida.

The largest turrid in the south Florida Tertiary, attaining a length of over 60 mm. Axial riblets are numerous (about 26) and rather close-set; they begin on the base just above the fasciolar keel and extend to the edge of the suture fasciole, the fasciole itself below the sutural cord being smooth. Aperture wide, the outer lip not thickened, bulging in the middle and with a small but deep stromboid notch below, the anal sinus above large, narrow and deep, generally bordered on the inner side by a large, thickened pad. Inner lip is formed by a large, thick, calloused shelf. Protoconch as figured.

Length 61.4 mm., diameter 24.2 mm.

A characteristic Pinecrest species but rare at all localities. Acline, Pinecrest, Miami Canal, Indian Reservation, Florida.

Family **CONIDAE**

Genus **CONUS** Linné, 1758

Type species by subsequent designation, Children, 1823, *Conus marmoreus* Linné. Recent, Indo-Pacific.

Conus presozoni, new species Pl. 79, figs. 2, 2a

Shell large, heavy, with a moderately high conic spire, nearly one-half the length of the body whorl below the shoulder, the body whorl large, wide at the shoulder, narrow and pointed at the anterior end. Dorsal surface of the spire whorls and between the shoulder and the suture of the body whorl is flat to slightly concave, marked with bowed growth lines of the anal fasciole and obscure, ill-defined spirals. The apical whorls are eroded but were apparently coronated. The surface of the body whorl is smooth except for a band of grooved spirals around the anterior canal portion. Siphonal canal notch wide, its end not recurved. The outer lip is thin, straight except for a marked inswing at the shoulder. Traces of the original color pattern are retained, and, as shown by the figures, consist of numerous spiral rows of small square spots.

Length 79 mm., diameter 41 mm. Holotype, USNM

Length 69 mm., diameter 34 mm. Paratype, PRI 6067.

Represented in the collection by six specimens, most of which retain traces of original color. The species by its shape and color pattern bears considerable resemblance to *C. sozoni* Bartsch of the Recent and is probably its ancestral form. The larger specimen has a prominent hump on the back due to a mended fracture.

Waccamaw formation. Crescent Beach Airport, Horry County, South Carolina.

Conus cherokus, new species Pl. 79, figs. 3-3b

The shell is relatively large, heavy, with a low spire of about nine whorls, the apical end more attenuated and approximately a fourth of the height of the body whorl below the shoulder. The shoulder is subangulated to mildly rounded, the suture placed a little below it so the coiling of spire whorls appears slightly scalate. Profile of the body whorl below the shoulder is nearly flat-sided or straight or a little convex. Surface smooth except for the growth lines which swing in sharply near the shoulder and are deeply but flatly bowed across the sutural fasciole; at the extreme anterior end, there is a band of wrinkled spiral threads, strong below but fading out above. Outer lip thin, straight as shown by the lines of growth, swinging in at the shoulder and into a wide flat-bottomed posterior sinus opposite the sutural fasciole. The anterior tip of the shell is broken away in the type destroying the siphonal canal notch but which was probably shallow, developing no fasciolar fold or twist in the pillar axis. Color white but with faint traces of square-shaped spots arranged spirally.

Height 69.5 mm., diameter 44.8. Holotype, USNM.

This is a member of the *Conus spurius* group but differs from any of the named forms by its shape. Only one specimen is known so far.

Waccamaw formation: Crescent Beach Airport, Horry County, South Carolina.

Subgenus **CONTRACONUS** Olsson and Harbison, 1953

Type species by original designation, *Conus adversarius tryoni* Heilprin. Caloosahatchee of Florida.

Conus (Contraconus) adversarius Conrad Pl. 79, figs. 1, 1a

Conus adversarius Conrad, 1840, Amer. Jour. Sci., vol. 39, p. 388; Conrad, 1841, *Idem.,* vol. 41, p. 345, pl. 2, fig. 3; Tuomey and Holmes, 1856, Pleiocene Fossils of South Carolina, p. 131, pl. 27, fig. 14.

The Waccamaw specimens of the left-handed cone represent the typical form characterized by a relatively short spire, the sutures not noticeably descending as in *C. adversarius tryoni* of the Caloosahatchee. Specimens showing traces of an original color pattern are relatively rare, a figure of such a shell based on a photograph shows the details clearly but on the shell itself is so faint as to be hardly discernible by the unaided eye. In adult specimens, the angle of the shoulder appears as if ridged or corded, and the surface of the body whorl below may be nearly smooth or marked with subobsolete spiral threads. The shell often becomes large and specimens exceeding 100 mm. are not uncommon.

Length 80 mm., diameter 41.3 mm. Figured specimen, USNM.

Waccamaw formation: Crescent Beach Airport, Horry County, South Carolina.

Family **CANCELLARIIDAE**

Genus **CANCELLARIA** Lamarck, 1799

Type species by monotypy, *Voluta reticulata* Linné. Recent, subtropical and tropical West Atlantic.

Cancellaria (Cancellaria) rotunda floridana, new subspecies Pl. 82, fig. 6

Shell large and heavy, similar to *C. rotunda* of the Duplin Miocene of the Carolinas, but still larger and with a longer spire. The figured specimen has five whorls, each whorl slightly shouldered or rounded at the suture, the suture being a little sunken. The spire whorls have a strong and even cancellate sculpture produced by intersecting, lightly inclined axials crossing strong, straplike spirals about five in number on the whorls preceding the penultimate, their squarish, flat-bottomed interspaces plain and smooth. On the body whorl, there are about 13 or more primary spiral cords, lower and each slightly double or bifid in appearance due to a small line along their middle, intersected by more closely spaced or crowded oblique axials, resulting in lower but neatly arranged nodes at their points of intersection. Interspaces between the spiral cords carrying a small interstitial thread which increases in strength below so that around the contracted base, the secondary threads equal the primary ones in size. Columella with three, sharp folds, the superior one much the largest. Pillar short, with a large, fasciolar fold around it arising from the deep, siphonal canal notch.

Length 80 mm., diameter 41.7 mm. Holotype, USNM.

Pinecrest beds: Brighton facies. Florida.

Subgenus **MASSYLA** H. and A. Adams, 1854

Type species by monotypy, *Cancellaria corrugata* Hinds. Recent, Panamic-Pacific Province.

Cancellaria (Massyla) propevenusta Mansfield Pl. 80, figs. 5-5b

Cancellaria (*Cancellaria*) *propevenusta* Mansfield, 1930, Florida State Geol. Sur., Bull., No. 3, p. 47, pl. 17, fig. 2. Harveys Creek, Leon County. (*Cancellaria* zone).

? *Cancellaria rapella* Johnson, 1904. Nautilus, vol. 17, No. 12, p. 143, text figure. Magnolia, Dauphin Co., North Carolina. Length 29 mm.

This fine species is fairly common at Pinecrest and full-grown specimens often attain a height of 60 mm. or more; it is rare at all other Pinecrest localities. The species resembles *C. venusta* Tuomey and Holmes but is much larger, with a shorter, more pointed spire and in general a larger more inflated body whorl. Typical Pinecrest shells have a medium-height spire of rounded, rapidly enlarging whorls, and a fusoid anterior canal encircled by a fasciolar fold generally enclosing a small, narrowly perforated umbilicus. The sculpture is formed by strong spiral cords, usually smooth or weakly beaded. There are two strong columellar plaits, and there is usually a long laminae on the parietal wall just below the lip junction. The outer lip is thin, slightly inclined and lirated within. A few measurements are as follows: height 61.2 mm., diameter 40 mm.; height 56 mm., diameter 46.6 mm. Both specimens from Pinecrest.

Well-developed specimens from Pinecrest usually have a moderately thin shell, and the encircling spiral cords are smoothish on top while shells from more northerly stations are more slender, heavier, and the spiral cords may be neatly beaded.

Pinecrest beds: Acline, Pinecrest, Florida State Indian Reservation, Indian Reservation, Brighton, Florida.

Genus **TRIGONOSTOMA** Blainville, 1827

Manuel de Malacologie et de Conchyliologie, vol. 2, p. 652.

Type species by monotypy, *Delphinula trigonostoma* Lamarck. Recent, Indo-Pacific.

The shell is loosely coiled, the whorls in contact for a narrow area, the base with a wide, open, deep umbilicus. The peristome is continuous, narrowly attached to the parietal wall, the outer lip thin or thickened by the final axial riblet. Columellar folds two or three, sometimes small or absent. The surface is sculptured with axials and spirals, sometimes nodose.

In the restricted sense, *Trigonostoma* does not occur in the late Tertiary and Recent faunas of America. The type species is an unusual Indo-Pacific species, its whorls hardly touching or in narrow sutural contact, the umbilicus wide. The columella bears three folds.

Subgenus **EMMONSELLA,** new subgenus

Type species herein designated, *Trigonostoma tenerum* (Phillippi). Recent, West Atlantic from Cape Hatteras southward.

Shell generally broadly ovate, with a medium height, scalate spire, with an angled shoulder and a rather wide, flattened sutural area sloping inward, the shell substance thin or heavy. The umbilicus is widely open, with an angled edge, the walls within smooth or sculptured. Aperture generally trigonal in shape, the flat base above, the apical angle downward and forming the siphonal canal. Pillar plaits two in number, small, placed well within and visible only by rotation. Surface nearly smooth or with strong sculpture of spirals, noded, or beaded axially.

A distinctive group of widely umbilicated American cancellarids usually referred to *Trigonostoma,* but they differ from the typical genus by their shorter stubbier form and more closely clasping whorls.

Trigonostoma (Emmonsella) carolinense (Emmons) Pl. 80, figs. 4, 4a

Cancellaria carolinensis Emmons, 1858. North Carolina Geol. Sur., Report., pp. 254, 255, fig. 118. It occurs at Mr. Flowers' marl bed on the Cape Fear, Bladen County, North Carolina.

Shell medium or large size and in the adult rather thick-walled, the body whorl large with an angled shoulder, bordered on the sutural side by a wide, flattened, or slightly depressed area, generally weakly sculptured sloping in towards the suture. The number of whorls in the figured specimen about six. The umbilicus is large, funnel-shaped, and penetrates deep into the inner whorls, its wall comparatively straight or flat, sculptured only with minute spirals except in some large adult specimens which show coarse irregular concentrics near the end. The surface sculpture below the shoulder consists mostly of small spiral threads, larger, and somewhat noded around the middle. The shoulder is generally armed with a row of small nodes, fairly evenly spaced on the penultimate and early part of the body whorl (11-12), irregular towards the end. Strong axial ridges resembling varices may show in the adult and mark former lip positions and in the large specimen figured, several are present; smaller shells have none. Aperture triangular, pointed and channelled, the parietal border calloused, adherent to the body whorl. Pillar with two plaits, long and narrow, partly hidden within.

Height 50.2 mm., diameter 39 mm. Pinecrest formation. Kissiminee, Osceola County, Florida, collected by Mrs. Jim Donovan, West Palm Beach, Palm Beach County, Florida.

Closely related to *T. tenera* (Philippi), 1848 of the Recent and to which it has often been referred but small differences exist. The fossil shell is often much larger and heavier than any specimens of the Recent species seen, which as the name implies is thin with a fine and uniform surface sculpture. There are two small columellar plaits, hardly visible from the outside.

Pinecrest beds: Brighton facies, Kissiminee, Florida.

Trigonostoma (Emmonsella) helenae, new species Pl. 80, figs. 3, 3a

Shell of medium size, thin, shaped as figured. Spire elevated, composed of about six whorls, shouldered so as to leave a wide space above which slopes unevenly down into the hidden suture, the base with a deep, funicular, flat-walled umbilicus, its apex penetrating deeply into the spire whorls. Surface sculpture is produced by fine, spiral threads imparting a linen-like pattern, in some cases, the surface is almost smooth, or a few of the threads being a little larger and more widely spaced, and one in particular around the middle of the body whorl, giving to it a slightly angular profile. There are no axials except for small weak nodes along the shoulder angle. The pillar wall is sloping, bearing two small plaits, not visible, except by rotation so as to be able to look more deeply into the interior. The outer lip is thin, smooth within.

Height 36.1 mm., diameter 29.1 mm. Holotype, USNM.

This interesting species is named for Mrs. Helen O'Brien of Daytona Beach, Florida, who collected it at Harney Pond. Other specimens have been collected along Miami Canal Levee. The species may be separated from *T. carolinense* by its fine spirals and smoothness.

Probably Pinecrest beds: Harney Pond; Miami Canal, Florida.

Trigonostoma (Emmonsella) elizabethae, new species Pl. 80, figs. 2, 2a

Shell similar to *T. carolinense* and *T. tenerum* in shape, with a high, tabulate spire, large, wide body whorl, strongly shouldered and with a deep, funnel-shaped umbilicus. The striking character of the shell is its coarse sculpture formed by four large, noded, spiral cords, the superior one on the shoulder being the largest and most heavily noded, its nodes sometimes rising to form sharp knoblike elevations. Two smaller noded cords encircle the mid-zone of the body whorl, and another forms the rim of the umbilicus, their interspaces covered with much smaller spirals giving to the general surface the textural pattern of a coarse cloth. Walls of the umbilicus are plain except for minute, hardly visible, spiral threads. Pillar with two small plaits, not directly visible except through rotation.

Length 45.1 mm., diameter 36.8 mm. Holotype, USNM.

Paratype, PRI 6069

This is the characteristic *Trigonostoma* in the Waccamaw beds at the Crescent Beach Airport near Ocean Drive Beach and Myrtle Beach. It is named for Mrs. Elizabeth Petit, wife of the junior author, for her cooperation in the collection of many of the fine shells in the Waccamaw deposits.

Waccamaw formation: Crescent Beach Airport and other nearby localities, Horry County, South Carolina.

Trigonostoma (Emmonsella) betsiae, new species Pl. 80, figs. 1, 1a

Generally similar to *T. elizabethae* but the encircling spirals are smaller and more numerous, the type showing six such cords between the shoulder and the umbilical rim; also, the whorls of this species are less angular than in *T. elizabethae,* giving this shell a more rounded appearance. The cords and their interspaces are covered with fine spiral threads. The shoulder angle on all the whorls carries a larger, wider cord and larger nodes than the cords below. Umbilicus deep, smooth walled or with fine spiral threads.

Length 36.4 mm., diameter 26.3 mm. Holotype, USNM.

Paratype, PRI 6068.

Named for Betsy Petit, daughter of the junior author.

Waccamaw formation: Crescent Beach Airport, Horry County, South Carolina.

Trigonostoma (————) druidi, new species Pl. 80, figs. 6, 6a; Pl. 82, fig. 8

Shell ovate, stubby and rather solid in texture, with sharply coronated, shouldered whorls, the small, elevated, tabulated spire rising steeple-fashion above and within a wide sunken space between the shoulder and suture on each whorl. Sculpture is produced by strong straplike spiral cords, crossed by inclined axials, forming low, nodelike elevations at their points of intersection and sometimes rising to form short recurved spines along the shoulder. On the early spire whorls, the spiral cords are simple, but they later become more straplike, flatter and cut into by one or more incised lines, the cords around the middle becoming irregularly bifid, while the shoulder cord, the widest of all, is incised by several lines so as to make it appear as if formed by several small threads strung together. The space between the shoulder and suture is wide, sunken, and excavated, smooth except for the axial ridges which cross it in a spinwheel-like fashion. The umbilicus is open, narrowly deep, its wall sculptured with a few spiral cords crossed by sharp-edged axial ridges. Pillar with two small plaits, the superior one larger.

Height or length 33.4 mm., diameter 25.6 mm. Holotype, USNM. 644651. Miami Canal.

A striking species, distinct from other West Atlantic *Trigonostoma,* fossil or Recent, recognized by its heavier shell and narrow umbilicus, the wall of which is sculptured with spirals and axials.

Pinecrest beds: Acline (Locklin Coll., USNM) ; Miami Canal (Type, Druid Wilson, USNM.) ; Indian Reservation, Olsson coll., Florida.

Order RACHIGLOSSA

Family **OLIVIDAE**

Subfamily **OLIVELLINAE**

Genus **OLIVELLA** Swainson, 1831

Type species by subsequent designation, Dall, 1909, *Oliva purpurata* Swainson (=*O. dama* Mawe).

Subgenus **DACTYLIDIA** H. and A. Adams, 1853

Type species by subsequent designation, Cossmann, 1899, *Olivella mutica* (Say).

Olivella (Dactylidia) druidwilsoni, new species Pl. 81, fig. 5

The shell is small, white, short, stubby, subovate, with a large body whorl widest about the middle and with a medium-height conic spire of five or more whorls. The parietal wall is covered by a narrow spread of callus, thin below, heavy opposite the upper end of aperture and extending across the penultimate whorl to the suture. The pillar structure is a strong, wide, plain fold continued above by a narrow, flat pad superimposed on the parietal callus about three-fourths of the distance along the inner lip. The posterior canal is formed by a long deep groove continuous with the suture and cutting across the callous growth at the end of the aperture. Surface of the body whorl is polished, sculptured around the middle by a rather high band of straight, axial ridges, plain and sharp along their crests or more or less weakly pustulated by four nodes each. The fasciole is a narrow enameled band set off sharply by a line above and marked along the middle by a slight furrow.

Length 13.5 mm., diameter 6.4 mm. Holotype, USNM.

Differs from other species of *Olivella* by the curious band of small axial riblets around the middle section of the body whorl. At first sight, this character might be thought abnormal, but at least 50 specimens have been seen, all marked the same way. It is a comparatively rare species in the Pinecrest beds at the type locality. Other important species of *Olivella* in the Pinecrest beds and which seem to have stratigraphic value are: *Olivella* (*Olivella*) *gladeensis* Mansfield is common in the typical Pinecrest along with *O.* (*Pachyoliva*) *tamiamiensis* Mansfield (*O. locklini* Olsson), also known from Alligator Creek. *O.* (*Toroliva*) *fargoi* Olsson and Harbison is common and characteristic of the Brighton facies of the Pinecrest throughout the northern area.

Family **VOLUTIDAE**

Genus **SCAPHELLA** Swainson, 1832

Type species by subsequent designation, Hermannsen, 1848, *Voluta junonia* Shaw. Recent, Cape Lookout, North Carolina, to Florida and the Gulf of Mexico.

Scaphella brennmortoni, new species Pl. 79, figs. 4-4b

Shell small or of moderate size, of the usual shape, the body whorl large, ovate-elliptical, the spire rather high and narrow composed generally of five or six whorls. The protoconch is scaphelloid, composed of one to three, smooth, eroded whorls, the apex generally rounded off. The first two or three post-nuclear whorls are sculptured with strong axial riblets and intervals overrun by much finer spirals; this early sculpture fading away on the third post-nuclear whorl, the spirals persisting longest so that even on the body whorl its surface is not entirely smooth but shows obsolete spiral lining. The axial riblets of the early spire whorls are constricted by an impressed spiral groove producing a coronated subsutural band which although soon fading away in its primary strength, its place is partly retained by an impressed band bordering the upper suture on all whorls. The outer lip thin, its edge nearly straight except for a strong inswing above into the suture, often forming a deep, posterior sinus, thickened by a fold which may form a definite shoulder against the suture. Columellar folds four, narrow, descending. Traces of the original color pattern are sometimes retained and show as spiral rows of large square-shaped spots.

Length 82 mm., diameter 33.7 mm. Holotype, USNM.
Length 106.5 mm., diameter 46 mm. Paratype, USNM.
Length 102 mm., diameter 39 mm. Paratype, USNM.
Paratypes (3), PRI 6071.

Although variable in shape, this *Scaphella* has definite characters of its own which warrant specific separation from *S. floridana* Heilprin of the Florida Caloosahatchee, its apparent nearest ally. The spire is higher, narrower so as to be decidedly drawn out, the sculptural stage persists longer and the posterior sinus is deeper, often developing into a strong subsutural foldlike shoulder.

Named for Messrs. Ray Brennan and Jim Morton of Myrtle Beach, South Carolina, in recognition of their valuable services during collecting.

Waccamaw formation: Crescent Beach Airport, Horry County, South Carolina.

Family **VASIDAE**

Genus **VASUM** Röding, 1798

Type species by subsequent designation, Herrmannsen, 1852. *Murex ceramicus* Linné. Wenz, 1946, p. 1300 or Winckworth, 1945, *Murex turbinellus* Linné.

Subgenus **HYSTRIVASUM** new subgenus

Type species herein designated, *Vasum horridum* Heilprin.

Species of *Vasum* in which the angled shoulder is armed with a crown of fluted spines, sometimes large and sharp, or reduced to small nodes, and with a similar row of spines or nodes bordering the suture on the outer side. The mid-surface of the body whorl between the shoulder and basal series of spines around the canal is encircled by four, five, or more large, spiral cords, sometimes with a smaller spiral in their deep, flat interspaces. Another series of spiniferous cords, to the number of three or four, encircle the anterior canal below the base. The anterior canal column is narrowly or widely umbilicated. Columellar pillar stout, bearing three or four small plaits, the upper one the largest. The siphonal canal notch is narrow and deep, pinched and curved, developing a fasciolar corded ridge forming the umbilical margin.

This subgeneric name is proposed for two striking species characteristic of the Caloosahatchee group; *V. locklini* Olsson and Harbison of the Pinecrest beds and *V. horridum* Heilprin of the Caloosahatchee marls. A third species may be present in the Tamiami, but to date, only a few impressions or molds have been recovered, too poor for specific determination. *V. locklini*, in typical form and several variants, appears to be restricted to the lower Caloosahatchee or Pinecrest beds with *V. horridum,* a more stabilized species, to the Caloosahatchee marls proper. The subgenus is, therefore, stratigraphically important, not known above the Caloosahatchee group.

Family **MURICIDAE**

Genus **PHYLLONOTUS** Swainson, 1833

Type species by subsequent designation, Gray, 1847. *Murex imperialis* Swainson (=*M. margaritensis* Abbott, 1958.) Recent, along the coast of Venezuela and northeastern Colombia.

The shell is normally large, rounded or apple-shape, the body whorl convex and with a short or medium-height stout spire, and a relatively short, wide, anterior canal, usually flattened along its ventral face and strongly recurved at the siphonal end. Each whorl has three or four riblike varices, widely spaced and which mark the position of the aperture at an earlier stage of growth. In the Recent species, such as *P. magaritensis* and *P. pomum,* the varices are solid, rounded on top and merely coarsely noded at the intersection points of the larger or primary spiral cords but in the earlier form (*P. globosus*), the primary spiral cords are sharply severed along the axis of the varices and again at the forward peristomal rim and rise to form high hollow or fluted sharp spines, inclined somewhat backwards; these varical spines are largest and longest on the back and apertural side of the anterior canal. Intervarical surface usually with a rib or node in the middle and overrun with primary and secondary spiral threads, wrinkled or sharply frilled by lines of growth. The aperture is rounded, its peristomal rim merging with the parietal callus, and hence continuous or interrupted slightly by the narrow slitlike cut over the siphonal channel of the anterior canal. The anal or posterior canal is a shallow groove or notch in the apertural callus, directed upward to the suture and lying appressed against the body whorl. The parietal callus is generally large and wide, spread outward as a large pad, often becoming free-edged and elevated at its outer margin, mainly over the base or opposite the columellar area. The surface of the parietal callus is smooth or weakly wrinkled in the columellar area. The peristomal rim of the outer lip is serrated by the ends of the wider spiral interspaces of the external sculpture and continues into the interior as lirations which are often paired. Operculum coarse, chitinous, unguiculate, and marked with strong growth lines.

We have examined a large series of the fossil, *P. globosus* and also a reasonable number of *P. margaritensis* from the coast of Venezuela (Margarita and Coche Islands). Our varix count of these two species has been invariably four; our varix count of *P. pomum* from many stations has been three. Our observations do not, therefore, support Abbott's[3] count of five (rarely six or four) for *P. margaritensis* or his general conclusion that it is unwise to accept such names as *Phyllonotus, Chicoreus,* and the like, on a generic or even subgeneric level because the characters used for their separation, mainly varix count, are too nebulous for general acceptance. Abbott's view has been contested by Myra Keen[4]. Where large number of species are involved and which differ so markedly from each other as do the muricids, it is highly important that the related species be segregated into smaller, more meaningful groups (whether on a generic or subgeneric level is relatively unimportant) based in part on a regional pattern of distribution extended back into geologic time if possible, even though if defined at present on rather uncertain or even so-called nebulous shell characters.

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[3] Abbott, Tucker, 1958, Acad. Nat. Sci. Philadelphia, Mon. No. 11, p. 61.
[4] Keen, Myra, 1959, Veliger, vol. 2, No. 1, p. 3.

Phyllonotus globosus (Emmons) Pl. 82, fig. 2

Murex globosa Emmons, 1858, Rept. North Carolina Geol. Survey, p. 247, fig. 105a.
Murex pomum Gmelin, Mansfield, 1930, Florida State Geol. Sur., Bull. No. 3, p. 83, pl. 11, fig. 9. Miocene of Florida.
Murex (*Phyllonotus*) *pomum* Gmelin, Gardner, 1948, U. S. Geol. Sur., Prof. Paper, No. 199-B, p. 219, pl. 29, figs. 22, 24. Waccamaw formation, Neil's Eddy Landing, N. Car; Olsson and Harbison, 1953, Acad. Nat. Sci. Philadelphia, Mon. No. 8, p. 243, pl. 34, fig. 1. Caloosahatchee, St. Petersburg, Florida.
Cf. *Murex margaritensis* Abbott, 1958, Acad. Nat. Sci. Philadelphia, Mon. No. 11, p. 61, plate 1n and o. (New name for *M. imperialis* Swainson, 1831, not G. Fischer, 1807).

Although this large *Murex* from the Caloosahatchee has usually been referred to *P. pomum* following the usage of Mansfield, Gardner, and others, it is now evident that it is much closer to *M. margaritensis* living today along the coast of Venezuela and northeastern Colombia, and some of the fossil specimens from Florida and the Carolinas are so similar to the Recent species as to warrant the use of the same name. In *P. pomum,* the whorls are shouldered rather than merely rounded, and the varical ribs are larger, and their foliation is less spiny, the sutural zone also less appressed. For the present, we have adopted Emmons name for this shell. This species is especially common in the Brighton facies of the Pinecrest, and specimens five inches or more in height are not uncommon. Both *P. pomum* and *P. globosus* occur together in the Caloosahatchee marl but are readily recognizable.

Genus **PTERORHYTIS** Conrad, 1868

Type species by monotypy, *Murex umbrifer* Conrad. Miocene of Virginia.

Subgenus **NEURARHYTIS** Olsson and Harbison, 1953

Type species by original designation, *Purpura* (*Pterorhytis*) *fluviana* (Dall). Upper Neogene of Florida.

Pterorhytis (Neurarhytis) marshalli (Mansfield) Pl. 81, figs. 3, 3a

Cerostoma umbrifer "Conrad" Tuomey and Holmes, 1856, Pleiocene fossils of South Carolina, pl. 28, fig. 14. Goose Creek.

Purpura marshalli Mansfield, 1930, Florida State Geol. Sur., Bull. No. 3, p. 84, pl. 11, fig. 4. *Cancellaria* zone, Leon Co., Florida.

Pterorhytis (*Neurarhytis*) *marshalli* (Mansfield), Emerson, 1959, Amer. Mus. Novitates, No. 1974, p. 5.

It seems likely that this is the shell figured by Tuomey and Holmes from Goose Creek, South Carolina, rather than *P. conradi* as so believed by Dall. There is also a question whether *P. marshalli* is specifically distinct from *P. fluviana* Dall from south Florida as there are wide differences between individual specimens as to the smoothness or cancellate aspect of the intercarical surface and other features.

Waccamaw formation: Crescent Beach Airport, Horry County, South Carolina.

Pterorhytis (————) seminola, new species Pl. 81, fig. 4

Shell purpuroid, of pale cream color, of medium size, stout, the spire and aperture of about the same length. Whorls five or more, the nuclear ones broken away. Varices heavy, rounded not winged, six on the last turn, more numerous on the spire whorls, formed by low, solid, axial ribs, slightly inclined and a little off-set at the suture, irregularly crenulated on the apertural side, the last varix large and forming a wide, stout rib along the edge of the outer lip. Whorls are sharply shouldered, indicated between the varices by a cord, around the middle on the spire whorls, the surface between the shoulder and suture smooth except for the growth lines, below, the surface has a few obscure spiral cords. Aperture subelliptical, whitish within, bearing a small, sharp tooth at the lower one-third, and a few, obscure denticles within; the shoulder cord may also show as a small apertural tooth. The varices of the body whorl terminate along the back of the anterior canal, as small, fluted stumps, the anterior canal of former apertures. The species is separated from other Floridian species of the genus by its large aperture, short anterior canal, and defoliated appearance.

Length 45.8 mm., diameter 27.8 mm. Holotype, USNM.

Pinecrest beds: Florida State Indian Resveration canal levee.

Genus **TYPHIS** Bruguière, 1810

Type species by original designation, *Purpura tubifer* Bruguière. Middle Eocene, Paris Basin, France.

Subgenus **TYPHINELLUS** Jousseaume, 1880

Type species by original designation, *Typhis sowerbiyi* [*sic*] Broderip (=*T. sowerbyii* Broderip). Recent, Mediterranean.

Typhis (Typhinellus) carolinensis, new species Pl. 81, figs. 1-1c

Shell relatively large, attaining a length of about 35 mm., slender, white, with a high spire of six or more whorls, about half the length of the body whorl conch. As usual there are four primary varices to each whorl, widely separated, their upper ends at the shoulder projecting as high, inwardly curved or coiled, tubular fingers; below, along the face of the body whorl, the varices show as narrow ridges, their edges coarsely frilled, and terminate below along the inner margin of the anterior canal, or at its end according to the earlier position of the lip to which they belong. The whorls are widely shouldered, the angle bearing, at its mid-point, a stout, outwardly directed tip, often long. Intervarical surface smooth, generally whitish. Aperture circular or ovate, edged with a continuous, rimmed peristome, the terminal varix somewhat winged, its forward face marked with four, spiral ridges. Siphonal canal roofed over and produced into a tubular extension at its end.

This species differs from *T. floridanus* Dall by its slimmer body whorl and larger size.

Length 32.6 mm., diameter 15.5 mm. Holotype, USNM.
Length 33 mm., diameter 17.7 mm. Paratype, USNM.
Paratypes (2), PRI 6070.

Family **MAGILIDAE** (Coralliophilidae)

Genus **CORALLIOPHILA** H. and A. Adams, 1853

Type species by subsequent designation, Iredale 1912, *Murex neritoidea* Chemnitz (=*Purpura violacea* Kiener).

Subgenus **BABELMUREX** Coen, 1922

Type species by original designation and tautonomy, *Fusus babelis* Requien. Recent, Mediterranean.

Coralliophila (Babelmurex) mansfieldi (McGinty) Pl. 82, figs. 4, 4a

Muricidae mansfieldi Mc Ginty, 1940, Nautilus, vol. 53, No. 3, pp. 83, 84, pl. 10, figs. 5, 5a. Clewiston, Hendry County.

The following description is based on a perfect specimen collected by Mrs. Helen O'Brien of Daytona Beach at Harney's Pond, Florida.

Shell of medium size, stout, with a high, scalate spire of six or more whorls, carinately shouldered around the middle, the shoulder angle separated from the suture by a wide area sloping upward. Sculpture is produced by weak axial riblets (about nine) which undulate across the base and along the shoulder where they form low, sharp nodes, and extend more weakly above the shoulder to the suture; in addition the whole surface is overrun by coarsely squamose spiral cords, larger on the base and there having a small subsidiary thread in their interspaces; much more numerous, finer, and more uniform on the shoulder-sutural area.

Height 33.3 mm., greater diameter 18.1 mm., length of aperture 17.9 mm. Harney Pond. Mrs. Helen O'Brien collection.

Apparently a rare species as only a few specimens are known so far, and because there has been some uncertainty about its status and relationship with a similar Recent form, it seemed desirable that the species should be refigured from an unusually well-preserved specimen. Mrs. O'Brien collected the specimen at Harney Pond canal levee which would seemingly indicate a Caloosahatchee marl horizon, but its precise stratigraphic level still remains a little uncertain.

? Caloosahatchee marl: Harney Pond levee (Mrs. H. O'Brien).

Family **BUCCINIDAE**

Genus **DORSANUM** Gray, 1847

Type species by original designation, *Buccinum politum* Lamarck.

Dorsanum ? plicatile (Böse) Pl. 79, fig. 6

Cominella plicatilis Böse, 1906, Institut Geologico de Mexico, Bol. 22, p. 39, pl. 4, figs. 22, 24. Mexico.

Dorsanum ? plicatilum (Böse), Cooke and Mossom, 1929, Florida Geol. Sur., 20th Ann. Report, pl. 16, fig. 3; Mansfield, 1930, Florida Geol. Sur., Bull., No. 3, p. 73, pl. 17, fig. 3.

Dorsanum ? plicatile (Böse), Tucker and Wilson, 1932. Bull. Amer. Paleont., vol. 18, No. 65, p. 52, pl. 9, fig. 6. Acline.

Although generally referred to *Dorsanum,* the generic relations of this shell appears more closely related to *Perunassa* Olsson from the late Neogene of Peru and Ecuador. Fairly common at Acline but rare at other Pinecrest localities. The specimen figured is from Miami Canal; it measures: Length 48.9 mm., diameter 23 mm.

Family **CHRYSODOMIDAE**

Genus **ECPHORA** Conrad, 1845

Type species by monotypy, *Fusus quadricostata* Say. Miocene of Maryland.

Ecphora quadricostata umbilicata (Wagner) Pl. 82, fig. 7

Ecphora quadricostata umbilicata (Wagner), Mansfield, 1930, Florida State Geol. Sur., Bull., No. 3, pp. 70, 71, pl. 17, fig. 7. Choctawatchee formation north Florida.

This characteristic Miocene shell has been found at several places in south Florida. It is most common in the Tamiami formation where large casts and molds are most frequent, especially through Charlotte County.

Ecphoras have often been found cast upon the beach between Fort Myers and Punta Gorda, and a fairly well-preserved specimen from Stump Pass near Chadwick was sent to the senior author some years ago. Lately Ecphoras in considerable numbers have been reported dredged along with Recent and Pleistocene shells from Port Coral near Fort Myers, Lee County, Florida.

As a Pinecrest fossil, *Ecphora* is extremely rare and only fragmentary specimens seen so far. Two fragmentary specimens (one herein figured) were found at Pinecrest by the senior author; other specimens have been reported from Indian Reservation and Brighton.

Order TAENIOGLOSSA

Family **TONNIDAE**

Genus **MALEA** Valenciennes, 1832

Type species by subsequent designation, Herrmannsen, 1847, *Malea latilabris* Val. Panamic-Pacific faunal province, coast of Ecuador.

The shell is globose with a large, rounded body whorl, the spire low or of medium height. Sculpture consists of large encircling spiral bands greatly thickened and set apart by a deep infold along the back, its inner edge serrated and lirated in harmony with the interspaces of the external spiral sculpture. The inner lip, simple in the juvenile, develops two, large, knoblike growths at maturity, one on the columella, the other on the parietal wall; each knob becomes plaited or noded as the shell attains greater maturity. The protoconch is turbinate or naticid of three or more smooth whorls, covered by a dark-colored periostracum.

Until lately, *Malea* was unknown in the Florida Tertiary although at least three species occur in the Caribbean Miocene. *Malea* is absent from the Caribbean or west Atlantic Recent fauna, but one, and perhaps two, species are living in the Panamic coastal zone from the Gulf of California south to northwestern Peru. The discovery of *Malea* in the Tertiary beds of south Florida was, therefore, an event of some importance. Principal occurrence of *Malea* in this area is in the Brighton facies of the Pinecrest, and at a few stations they have beeen found in fair numbers. A few fragments of the outer lip of a much larger *Malea* than that of the Pinecrest was obtained from the Caloosahatchee marl at the excavation site for Pump Station No. 8 on the Miami canal and which probably belongs to another species. Internal molds of *Malea* are common in the Tamiami formation at many places.

Malea densecostata (Rutsch) Pl. 79, figs. 5, 5a

Tonna (*Malea*) *ringens densecostata* Rutsch, 1934, Abhl. der Schweiz. Palseont. Gesellschalft. Bd. liv., pp. 60-62, Taf. 111, figs. 6, 7. Punta Gavilan schicten, Punta Gavilan, Venezuela. Upper Miocene or Pliocene. The type is a relatively small shell measuring height 77 mm.

Malea elliptica Pilsbry and Johnson, Olsson, 1922, Bull. Amer. Paleont., vol. 9, No. 39, p. 311, pl. 15, fig. 2. Not of Pilsbry and Johnson, 1917. Miocene, Banana River, Costa Rica.

Malea ringens (Swainson), Anderson, 1929, California Acad. Sci., Proc., 4th ser., vol. 18, No. 4, p. 140, pl. 12, figs. 3, 4. Not of Swainson. Miocene of Tubara, Colombia.

Florida specimens of this *Malea* are rounded or ball-shaped, solid in texture, the body whorl large and with a low to medium-height spire of five or more whorls separated by sharp sutures. The nuclear whorls have not been found preserved on any specimen seen. Primary sculpture is produced by large, strong, encircling bands or cords (17 or 18 on the body whorl) separated by interspaces of about the same width. These interspaces may be simple and plain, more often, they carry a secondary cord which may fill it so fully that only a deep groove separates the interstitial cord from the adjacent primary one. At maturity, the lip is enlarged and bent sharply outward forming a wide, flat face, usually strongly lirated, each liration placed directly under an external interspace, and whether simple or paired depending upon the presence or absence of the interstitial cord in the external interspace. There are two large knobs on the inner lip, one on the parietal wall which may be double or triple lirated, and a similar one on the pillar.

Height 109 mm., diameter 88.6 mm. Figured specimen, Indian Prairie Levee. USNM.

Differs from the members of the *M. ringens-camura* group by its more numerous, lower, encircling bands and with the double or grooved lirations along the forward face of the reflexed outer lip. The Florida specimens appears to have a more rounded shape than that ordinarily seen in *M. ringens* and its allies.

This species of *Malea* was described by Rutsch (as a subspecies of *M. ringens*) from Punta Gavilan, District of Zamora, on the north coast of Venezuela, from beds generally known as the Punta Gavilan formation (Liddle, 1946, p. 534). Geologists, who have mapped the section at Punta Gavilan, agree in placing the beds in the Upper Tertiary (late Miocene or early Pliocene), an age assignment which agrees with that of the *Malea* horizon in south Florida. Rutsch's illustration of his *M. densecostata* is based on a relatively small shell (height 77 mm.), but it agrees well with our Florida shell in essential characters. A specimen of a *Malea* in the collection of the senior author from the upper Tubera Miocene of Colombia appears to be *M. densecostata* rather than a form of *M. ringens* to which other Colombian specimens of the same species was referred to by Anderson, (1929). The Costa Rican *Malea* from the Miocene of the Banana River, assigned by Olsson (1922) to *M. elliptica* Pilsbry and Johnson, 1917, (at the time unfigured) is apparently also *M. densecostata.* These few records show that *M. densecostata* had a large distribution through the Caribbean region northward to Florida during late Neogene times.

Pinecrest beds: Indian Prairie levee and at several other places in the Brighton facies through Glades and Highland Counties.

Family **CASSIDIDAE**

Genus **MORUM** Röding, 1798

Type species by monotypy, *Morum purpureum Röding* [=*M. oniscus* (Linné)].

Subgenus **ONISCIDIA** Swainson, 1840

Type species by elimination (see Gardner, 1947, U.S.G.S. Prof. Paper 142-H, p. 538), *Morum cancellatum* Sowerby. Recent, Indo-Pacific.

Differs from typical *Morum* by its stronger sculpture.

Morum (Oniscidia) obrienae, new species Pl. 83, figs. 8, 8a

The shell is of medium size, solid, barrel shaped, the body whorl large forming three-fourth of the whole length, with the small scalate spire elevated above it. Whorls about seven including the small turbinate nucleus of one and a half turns. Change from the nuclear stage to the nepionic is abrupt, indicated by a dividing varix, assumption of sculpture and the formation of a sharply angled, peripheral shoulder. Space above the shoulder is wide, undulated by the extension across it of weak axial ridges set between wider, axial depressions. On the body whorl, the sculpture is coarsely cancellated by large coarse spiral cords (about seven between shoulder and canal) crossed by small axials forming deep, wide, meshlike interspaces between them. At the shoulder, the axials rise into short, sharp points, fluted on their inner sides. Overrunning the cords and interspaces is a series of smaller spirals, fairly regular in size, except on the shoulder cord where they are larger and irregular so that the shoulder cord appears composite. Aperture nearly as long as the body whorl, nearly elliptical in form, the outer lip thickened by a raised rib, and strongly denticulated along its inner side. Parietal callus wide, free-edged, bearing numerous large and small denticles over it.

Height 29.5 mm., diameter 18 mm. Holotype, USNM.

This species is related to both *M. domingense* Sowerby of the Dominican Miocene and to *M.* (*O.*) *chipolanum* Dall of the Chipola Miocene of Florida. It differs from both by its coarser lattice-like sculpture and less strongly developed parietal callus.

From *M. macgintyi* Maxwell Smith[5], this species differs by its more slender form and in various sculptural details, there being seven cords encircling the body whorl while there are nine on *M. macgintyi.*

Caloosahatchee marl: Fort Denaud [Denaud], Lee County, Florida.

Superfamily **CYPRAECEA**

Family **CYPRAEIDAE**

Genus **SIPHOCYPRAEA** Heilprin, 1887

(Section *Akleistostoma* Gardner, 1948)

Type species by monotypy, *Siphocypraea problematica* Heilprin. Caloosahatchee of South Florida.

Cypraeas in which the apical whorls of the immature shell lie in a cup-shaped depression or crater, with the tip of the protoconch rising like a small pimple in the middle. As the shell grows, the floor of the depression becomes covered with callus, its outer lip edge rises and as the anal canal develops into the mature form, its margin becomes thickened and elevated; the posterior or anal canal may remain as a simple notch or as in the more advanced species, it may develop into a deep, curved, spiral, or comma-shaped sulcus. The development of the fossula is variable from obscure with a flat wall to well defined and deeply excavated. The extreme anterior margins of the shell are sometimes enlarged into shovel-nosed flattened flanges.

In this study, *Siphocypraea* is given full generic status differing from other Cypraeas by its depressed spire in the Bulla or juvenile stage. It is probably an endemic American group with its early roots in Oligocene times.

As fossils, Cypraeas are generally rare in most Tertiary formations, and seldom more than a few specimens are ever collected from one locality.

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[5] *Morum macgintyi* Maxwell Smith, 1937, Nautilus, vol. 51, No. 2, pp. 67, 68, pl. 6, fig. 12. Clewiston. (? Unit A.)

In contrast, *Siphocypraea* may be extremely abundant in the Caloosahatchee group, constituting one of the most common and conspicuous forms in a fauna already famous for many striking species.

The late Tertiary *Siphocypraea* of Florida belongs to two species groups, of which the two end forms, *S. carolinensis* of the Duplin and the Caloosahatchee marl *S. problematica* differ greatly from each other, but they are fully connected in the lower Caloosahatchee or Pinecrest beds by an endless series of variants. At Pinecrest itself, the representative form is *S. carolinensis floridana* Mansfield; but at Brighton and many other localities north of Lake Okeechobee, variation in form, width of the aperture, and in the size and depth of the posterior canal become extreme. How many of these variations should be named is debatable. Two forms will be described in this paper because they are striking and may later have some stratigraphic significance.

As here understood, the genus *Siphocypraea* of Heilprin comprises two main group of species, which may be considered as subgenera.

Subgenus *Siphocypraea s.s.*, type species, *S. problematica* Heilprin (*Akleistostoma* Gardner, 1948 is a synonym, as its type species *S. carolinensis* (Conrad) is phylogentically connected with the later *S. problematica*). True *Siphocypraea* became extinct at the close of Caloosahatchee marl deposition and is unknown from the overlying Unit A.

Subgenus *Muracypraea* Woodring, 1957. Type species, *Cypraea mus* Linné. Recent, southern Caribbean. The species group, *S. henekeni* (Sowerby) was widespread during Miocene times throughout the Caribbean region and along the Pacific Coast as far south as Ecuador. This species complex is recognized in having usually two dorsal nodes over the hidden apex as well as by its shape and strong anterior-lateral flanges. The group has so-far not been found in Florida, although some forms of the *Siphocypraea carolinensis-problematica* complex may approach it.

Siphocypraea (Siphocypraea) carolinensis carolinensis (Conrad)

Pl. 83, figs. 1-1b

Cypraea carolinensis Conrad, 1841, Amer. Jour. Science, 1st ser., vol. 41, p. 346, pl. 2, fig. 6. Natural Well, Duplin Co., N. C.; Tuomey and Holmes, 1856, Pleiocene fossils of South Carolina, p. 126, pl. 27, figs. 1, 2; Emmons, 1858, Rept. North Carolina Geol. Sur., p. 260, fig. 131; Dall, 1890, Wagner Free Inst. Science, Trans., vol. 3, pt. 1, pp. 165, 167.

Cypraea (*Cypraeorbis*) *carolinensis* Conrad, Gardner, 1948, U. S. Geol. Sur., Prof. Paper No. 199-B, p. 214, pl. 29, figs. 2, 7 (as section *Akleistostoma*).

A full-grown specimen from Natural Well, figured in this work, has a wide, semiovate, squatty form, with a low, broadly rounded dorsum, and a nearly flat, ventral side or base. The aperture is fairly wide, and at the posterior end, swings left over the hollow above the covered spire, wider near the anterior end, narrowing suddenly along the borders of the siphonal canal, its labial side crenulated with small, evenly spaced denticles, stronger in the middle section. Denticles on the parietal lip side are smaller, weaker, irregular, and partly alternate in spacing. Fossula obscure, wall with flat, smooth side. Siphonal notch rounded at end, sharply rimmed, the anterior margins of the shell terminating in short, flattened flanges.

Length 78.8 mm., height 34.7 mm., diameter 50.2 mm. Natural Well, Duplin County, North Carolina. Coll. C. R. Locklin. ANSP, 18859.

Siphocypraea (Siphocypraea) carolinensis floridana (Mansfield)
Pl. 83, figs. 2-2b

Cypraea carolinensis floridana Mansfield, 1931, U. S. Nat. Museum, Proc., vol. 79, art. 21, p. 6, pl. 1, figs. 2, 6, 7. Tamiami Trail, 42 miles west of Miami, Dade County, Florida.

Cypraea carolinensis floridanus Mansfield, Ingram, 1942, Bull. Amer. Paleont. vol. 27, No. 104, p. 103, pl. 8, figs. 3, 4.

The full-grown shell may be large (length 82 mm. or more), fairly solid, broadly subovate to subelliptical, the dorsum uniformly convex, the ventral surface flat, sometimes decidedly impressed near the anterior end, the sides rounded or slightly flattened and covered by a wash of callus extending upward towards the dorsum one-third to one-half way. The aperture is of medium width, curved towards the left above, wider in the lower section, except at the anterior end where it narrows abruptly to form the margins of the anterior canal. There is a row of 24 to 26 strong teeth on the labial side and 18 to 20 smaller ones on the parietal side. No fossula, the wall within is straight and smooth. The anterior-dorsal extremity is narrowly flattened as if pinched in from above, assuming the shape of a small shovel-like plow. The posterior canal is a deep, slightly inclined, straight sulcus, terminating in a shallow notch over the hidden apex. Young specimens with thin lip have a delicate, fragile shell with a low, depressed, sunken spire, the protoconch, when it is shown, formed of 1½ large whorls which project slightly about the crater-like depression in the middle. Young shells show also an anterior or fasciolar fold, nearly parallel with the straight anterior canal and terminating at the end in the siphonal canal notch. Some specimens show faint mottling along the sides, the trace of an earlier color pattern.

Length 81.1 mm., diameter 45.9 mm., height 35.7 mm. Pinecrest.

This cypraeid is characteristic of the Acline and Pinecrest beds and at the type locality is fairly common. Like other species of the genus, the shell varies considerably in shape from rather short, subovate forms to others of a more elliptical outline. The posterior sulcus is a straight, slightly inclined cut without any indication of curve or coil.

Siphocypraea (Siphocypraea) carolinensis hughesi, new subspecies

Pl. 83, figs. 5-5c

Shell variable in size, often large, heavy, broadly elliptical, widest just above the middle line, the dorsum generally wide, low, broadly rounded. The base is wide, flattened, or a little humped on the body whorl side, the outer lip side wide, the anterior end strongly impressed over the end of the aperture. The aperture is narrow and of nearly uniform width throughout, strongly curved above to the left, only a little wider in the anterior section. Outer lip is finely toothed throughout (with about 21 teeth in the type), the inner or parietal side with longer, narrower, and somewhat irregular lirations. The anal or posterior canal is a deep sulcus, sunken, and excavated over the apex, its sides raised. Anterior end of shell with short, plowlike, pinched-in flanges. This form differs from the typical by its squat shape.

Length 65.6 mm., diameter 46.7 mm., height 30.3 mm. Holotype, USNM.

Pinecrest beds: Brighton facies, Slough Ditch, about five miles east of Brighton, Highlands County, Florida (Olsson 1098).

Siphocypraea (Siphocypraea) carolinensis transitoria, new subspecies

Pl. 83, figs. 3-3b

Shell large, oblong-subovate, with a moderately high, convex dorsum and a flattened base, the ventral face of the outer lip and body whorl together lying nearly in the same, flat plane, their lateral margins subangulated to weakly rounded. Aperture is intermediate between that of *S. carolinensis* and *S. problematica,* narrow and strongly curved to the left above, wider in the anterior one-quarter section, and in front of that deeply impressed on both sides over the siphonal canal. The labial margin of the outer lip is sharply lirated throughout, the lirae on the parietal side longer and narrower. Fossula distinct, excavated, with a strong, bounding ridge within. The posterior canal is a deep, half-circle sulcus, hollowed out within above the buried apex with a high sharp rim elevated prominently above it on the left or body whorl side. Siphonal canal notch deep, rounded, pinched in at the entrance and sharply rimmed. Surface of the dorsum shows longitudinal growth lines in the middle zone covered by a glaze of enamel on the sides.

Length 81.6 mm., height 37.4 mm., diameter 51 mm. Brighton. Holotype, USNM.

Pinecrest beds: Brighton facies, Brighton, Highlands County, Florida.

Siphocypraea (Siphocypraea) problematica Heilprin Pl. 83, figs. 4-4b

Siphocypraea problematica Heilprin, 1887, Wagner Free Inst. Sciences, Trans., vol. 1, pp. 87, 133, pl. 4, figs. 12, 12a, 12b; pl. 28, figs. 2, 73; Ingram, 1942, Bull. Amer. Paleont., vol. 27, No. 104, p. 108, pl. 10, figs. 10, 11.

Cypraea problematica (Heilprin), Dall, 1890, Wagner Free Inst., Trans., vol. 3, pt. 1, p. 167, pl. 5, figs. 10, 10b.

Cypraea (*Siphocypraea*) *problematica* (Heilprin), Olsson and Harbison, 1953, Acad. Nat. Sci. Philadelphia, Mon. No. 8, p. 262, pl. 27, figs. 2, 2a.

This fine species is common in many localities in the Caloosahatchee varying considerably in size and to some extent in shape. It is typically elongate-elliptical, a little wider in the posterior half, the dorsum high and evenly convex, its sides smoothly rounded. The ventral face is not noticeably flattened and on the whole narrow. The aperture is uniformly narrow, not noticeably enlarged in the anterior portion; both lip margins evenly and strongly toothed throughout, there being 26 or 27 teeth usually on the labial side, and about 26 on the parietal side. The fossula is distinct, showing as a deeply excavated area below by a sharp ridge. The posterior canal forms a deep, semicircle or comma-shaped sulcus over the apex, giving the shell its most striking characteristic. Surface generally with a high gloss, white or a rich fawn color, sometimes mottled and retaining trace of a pattern consisting of small scattered brown spots.

S. problematica is believed to be largely restricted to the typical Caloosahatchee or to the Caloosahatchee marls proper. In these beds, the shell is generally finely preserved showing a high surface gloss, and specimens colored deep amber brown over the dorsum with traces of pattern in the form of small spots are not uncommon. The species is also found at several places north of Lake Okeechobee along several levees or canal embankments in association with Pinecrest *Siphocypraea.* Specimens with a high gloss were possibly derived from an overlying bed of the typical Caloosahatchee marls but others have the dull chalky surface generally shown by *S. carolinensis* variants.

Siphocypraea (Siphocypraea) chilona (Dall) Pl. 83, fig. 6

Cypraea chilona Dall, 1900. Wagner Free Inst. Science, Trans., vol. 3, pt. 6, pl. 39, figs. 1, 3 (no description). Alum Bluff, Liberty County, Florida; Ingram, 1939, Bull. Amer. Paleont., vol. 24, No. 84, p. 4, pl. 1, figs. 3, 4.

Cypraea (*Cypraeorbis*) *chilona* Dall, Gardner, 1947, U. S. Geol. Sur., Prof. Paper No. 142-H, p. 541, pl. 54, figs. 4, 5.

This is a lower Miocene or Chipola species. In profile view, the shell has a broadly elliptical to nearly circular outline, with a high, convex dorsum, decidedly impressed over the buried apex, a flattened base without angulated sides. The posterior canal is a high, slightly oblique cut, not enlarged at the end. Aperture relatively narrow, nearly uniform throughout, with even crenulations on both lips (aperture is well shown in Gardner's figure). The fossula is well marked, and shows as a small sunken area bounded within by a sharp pillar keel.

A section across the dorsum of a specimen from Ten Mile Creek in the Locklin collection reveals the pattern of the inner whorls to be similar to that shown in similar sections of *S. carolinensis* and *S. problematica,* the original apex being low or depressed.

Length 51 mm., diameter 41.7 mm., height 32.6 mm.

Chipola beds: Ten Mile Creek, Calhoun County, Florida (Locklin coll.) USNM.

Family **STROMBIDAE**

Genus **STROMBUS** Linné, 1758

Type species by subsequent designation, Montfort, 1810, *Strombus pugilis* Linné. Recent, Florida and the West Indian-Caribbean region.

Strombus williamsi, new species Pl. 81, fig. 6

The shell is large, shaped like *S. gigas* but differing in the weaker development of the shoulder spines which in the type specimen are present only on the shoulder of the penultimate whorl and the whorl above, lacking from the earlier spire whorls and on the back and final portion of the body whorl. The spire is broad, forming a low, nearly straight-sided cone, except for the short spinelike nodes of the penultimate and preceding whorl, the suture fine, appressed against the shoulder above, undulated around the shoulder nodes where these are present. Surface of the spire whorls is marked with low spiral cords, heaviest on the upperhalf, hardly developed in the lower section and over the shoulder nodes. Main surface or that of the body whorl below the shoulder is covered with low spiral cords which in the type show a tendency towards a weak banding, in groups of three, four or more. Outer lip expanded, produced a little above, its outer edge somewhat thickened, not showing any definite stromboid notch. Parietal wall covered by a coat of callus.

Length 230 mm., diameter 155 mm.

Related to *S. gigas* Linné of the Recent fauna but differing by its more conical spire, and in the much weaker development of shoulder spines, absent from the early spire whorls and from the back of the body whorl.

This fine species is named to honor George Gernand Williams of Miami, Florida, who collected the type specimen along the Indian Reservation levee.

Family **CYMATIIDAE**

Genus **CYMATIUM** Röding, 1798

Type species by subsequent designation, Dall, 1904, *Murex femorale* Linné.

Subgenus **LINATELLA** Gray, 1857

Type species by monotypy, *L. cingulata* Lamarck.

Cymatium (Linatella) valentinei new species Pl. 82, figs. 1, 1a

The shell is relatively large, fairly heavy, ovate-fusiform in shape, with a rounded, *Tonna*-like body whorl and an elevated spire of six or more whorls, about equal in height to that of the aperture. The whorls are distinctly shouldered, the shoulder is emphasized by the large, noded, faintly double cord along it. The sculpture is dominantly spiral, produced by a series of large primary cords of which there are six on the body whorl and two showing on the penultimate and earlier whorls of the spire. The primary spiral cords are well separated, their interspaces carrying one or two smaller spirals along each one. Above the shoulder, there is a fairly wide area sloping towards the suture, sculptured with small spiral cords or threads along it. No varix is present on any of the whorls, but the surface is crossed by fairly strong longitudinals at more or less equal intervals which rise into low nodes as they cross the primary spiral cords on all whorls. The base is sharply contracted and extended into a medium-length anterior canal, straight above, but bent backward in the lower part and at the end bearing a deep, siphonal canal notch. Back of the anterior canal is sculptured with small alternating spiral cords. The outer lip has a rounded profile, thickened a little, furrowed and fluted within by the deep, wide, primary interspaces.

Length 120 mm., diameter 75 mm. Holotype, USNM.

The fossil is nearest to *C. wiegmanni* (Anton), a species of the Panamic-Pacific faunal province ranging from the Gulf of Panama southward to northwestern Peru. The Pacific shell differs mainly by its much weaker sculpture, only the shoulder cord being large and noded.

The holotype of this fine species was collected at Brighton, Highlands County, Florida, by Dr. Mason Valentine for whom it is named. A smaller specimen from Indian Prairie levee is in the Olsson collection. The second specimen bears a still greater resemblance to *C. wiegmanni* in that the spiral interspaces have but one and not two spiral cords. Another large specimen of *C. valentinei* is in the Hughes collection at the U. S. National Museum, obtained at Brighton.

Pinecrest Beds: Brighton; Indian Prairie.

Family **CALYPTRAEIDAE**

Genus **TROCHITA** Schumacher, 1817

(*Trochatella* Lesson, 1830; *Trochala* Swainson, 1840;
Clypeola Gray, 1867.)

Type species by subsequent designation, Rehder, 1943, *Trochita spiralis* Schumacher [=*T. radians* (Lamarck)].

The shell is cap or cone-shaped, low or high, sometimes distorted, with a spirally coiled suture beginning at the apex which is usually placed a little off-center. Base almost circular and resembling a suction cup and provided internally with a large spiral lamellae wound around an imperforate columellar axis. The nuclear whorls have a naticid coil and smooth surface. The sculpture of the adult shell is produced by weak or strong axial riblets, more rarely smooth, the whole covered by a deciduous brown periostracum.

Trochita floridana, new species Pl. 81, figs. 2, 2a

In shape, the shell varies from a rather low, caplike cone to high, often distorted forms. The specimen selected as holotype and figured has a nearly circular base, sharply serrated by the ends of the axial riblets on the forward or anterior side so as to resemble the teeth of a gear or a circular saw. A spiral surface suture of about three turns cuts across the axial riblets distinctly but without interrupting their general continuity and alignement. Sculpture is produced by high, coarse, axial riblets, placed so closely that their interspaces show as deeply inset grooves. There are about 42 axial riblets on the last whorl, most of which extend above to the suture, with other smaller axials intercalated below. On the inside, the surface of the spiral lamellae is nearly flat and extends almost to the outer shell margin, the growth lines of the internal lamellae slightly sinuous. Color of most shells is white except when stained by the matrix.

Height 23.8 mm., diameter 53.8 mm. Holotype, USNM.

Height 34.4 mm., diameter 60.7 mm. Paratype, USNM.

Differs from the usual form of *T. radians* (Lamarck) of the Recent Peruvian fauna by its stronger, coarser, and more closely packed radial ribs and from *T. spirata* of Mexico by its fewer, more open sutures, and in details of its sculpture.

The occurrence of *Trochita* in the lower Caloosahatchee deposits in south Florida has been known for several years but earlier specimens were poorly preserved, unfit for naming and illustration. A few poor specimens were found by Mr. C. R. Locklin at St. Petersburg while others in greater number had been collected by Druid Wilson in a shell pit near Moore Haven still earlier. The first finding of Trochitas in numbers and in good condition was made by Miss Muriel Hunter along Fish Eating Creek just above the bridge crossing on Route 68 during dredging operations in that area a few years back. These specimens were in an exquisite state of preservation rivalling that seen amongst examples of the Recent species in any museum collection. Trochitas have also been found in large numbers along the banks of the Kissimmee River in dredged material as first reported to us by Mrs. Jim Donovan of West Palm Beach.

Trochita floridana is a member of the Brighton facies of the Pinecrest or of the lower Caloosahatchee, its common associates in the area northwest of Lake Okeechobee being *Mulinia congesta, Mytilus incrassata, Raeta undulata, Semele harveyensis, Malea, Ilyanassa floridana.* Casts and molds of a *Trochita* are common in the Tamiami formation, but none have been found in the typical Caloosahatchee marls so far.

A review of Recent *Trochita* has been given by Rehder who reported four species and a doubtful fifth. Of American species, the two best known, both Pacific, are; *T. radians* (Lamarck), distributed along the coast of South America from about mid-Peru to Chile and around through the Magellan straits to southern Argentine and the Falkland Islands; the other American species not mentioned by Rehder is *T. spirata* Forbes from the coast of Mexico. According to Keen (1958, p. 312), specimens (*T. spirata*) may be found clinging tenaciously to the most surf-beaten rocks on exposed coasts, especially at Manzanillo. The best known species of the genus is *T. radians* (Lamarck) found plentifully along the middle Peruvian coast south of Callao, perched on rock surfaces associated with *Concholepas*, various limpets and chitons, exposed to the pounding of heavy surf waves generated by the great Pacific swells which sweep in ceaseless even on the calmest days. This *Trochita* is especially common along Paracas Peninsula and in the Bahia de la Independencia, Peru, its cast-up, beaten shells accumulating in long wind-rows behind the protecting rocky headlands. *T. radians* is a cold-water species of the Humboldt Current, thinning out north of Callao to disappear entirely before attaining the latitude of the Lobos Islands and Sechura Bay, Peru. Northerly records from Peru and Ecuador (Manta, cited by Dall, and Rehder) have not been verified and must be discredited.

Trochita was probably widely distributed through the Caribbean region during Miocene times but records are relatively few. Woodring illustrated specimens from the Gatun of the Canal Zone under the name *T. trochifomis* (Born) (Not Born) (=*T. radians* (Lamarck). His figure of the largest specimen shows an evenly enlarging spiral coil and short, heavy axial ribs more suggestive of the Mexican *T. spirata* than of the Peruvian species. He also recorded other remains of *Trochita* from the middle member of the Caimito, indicating an extension back in time to the late Oligocene. A specimen of a large *Trochita* was collected by the senior author from the Tubara Miocene of Atlantico, Colombia.

Family **CERITHIIDAE**

Genus **CERITHIUM** Bruguière, 1789

Type species by tautonymy, *Cerithium adansonii* Bruguière (*C. erythraeonense* Lamarck). Recent, Red Sea.

Subgenus **CERITHIOCLAVA** Olsson and Harbison, 1953

Type species by original designation, *Cerithium caloosaense* Dall (*C. ornatissimum* Heilprin). Caloosahatchee of Florida.

Cerithium (Cerithioclava) dalli, new species Pl. 82, figs. 3-3b

Shell large, heavy and solid (length up to about 100 mm.), with a stout, moderately slender spire of eight or more, flat-sided whorls, the sutures so fine as to be hardly distinguishable. Sculpture on the mature whorls is similar on all specimens, consisting of a series of low, alternating, finely noded, banded spirals, the sutural cord being the largest, no axial riblets being present except on the earliest spire whorls. A few, low, humplike varices are distributed irregularly along some of the spire whorls and a large, prominent, humped varix is always present on mature specimens on the left-hand side or opposite to the aperture. At maturity, the aperture is obliquely lanceolate, the ends drawn-out into an anterior and posterior canal; the outer lip is strongly thickened on the back, somewhat expanded, finely lirated on the inner side. The posterior canal is well developed as for the subgenus, the anterior canal recurved at the end.

Length 86.4 mm., diameter 30.6 mm. Holotype, USNM.

Length 70 mm., diameter 24.6 mm. Paratype, USNM.

Much larger and more solidly build than *C. caloosaense*, also with finer, more uniform sculpture.

Pinecrest formation: Miami Canal; Pinecrest, Florida.

PLATES

Explanation of Plate 77

Figure Page

1. **Pododesmus rudis** (Broderip) 529

Figured for comparison with figure 2. The lower valve, broadly cemented to the substrate and showing the central chalky area, the single crural process, adductor scar, and the byssal plug. Greater diameter 49 mm. Recent, Key West, Fla. Olsson collection.

2-2c. **Pododesmus waccamawensis** (Gardner) 530

Fig. 2. A small, upper valve showing the strongly ribbed sculpture. Height 28.8 mm. Fig. 2a. Enlargement of the top of the crural process showing the bilobate shape of the resiliferal scar. Fig. 2b. Interior of a lower valve (same shell as fig. 2a.) showing the central white area with inclosed byssal plug, the adductor muscle scar below and the crural elements along the dorsal-posterior sides. Height 47 mm. Fig. 2c. Interior of upper valve showing the central white area and two scars, the upper being that of the byssal retractor, and the lower, that of the adductor muscle. Height 68 mm. Waccamaw formation. Cresent Beach Airport, S. C.

3, 3a. **Panopea dockensis,** new species 536

Exterior and interior of a right valve. Length 158 mm. Holotype, USNM 644638. Waccamaw formation, Old Dock, N. C.

4-4b. **Anadara (Caloosarca) rustica** (Tuomey and Holmes) 527

Fig. 4. A small left valve, length 23.6 mm. Fig. 4a. A larger right valve, length 46 mm. Fig. 4b. Dorsal view of a large specimen showing the high cardinal area marked with crowded ligamental grooves. Length 74 mm. Waccamaw formation, Crescent Beach Airport, S. C.

5. **Cymatoica marcottae,** new species 534

A small right valve, length 10 mm. Holotype, USNM 644639. St. Petersburg, Fla. Coll. Mrs. Edna Marcott.

6, 6a. **Nioche marcottae,** new species 532

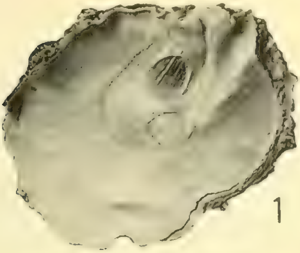
Fig. 6. A right valve, length 28.1 mm. Fig. 6a. Hinge of the same valve, magnified. Holotype, USNM 644640. St. Petersburg, Fla. Coll. Mrs. Edna Marcott.

7, 7a. **Lima (Promantellum) florpacifica,** new species 529

Figures of the same specimen, external and internal views. Height 27.2 mm. Holotype, USNM 644641. St. Petersburg, Fla.

8. **Macoma** cf. **constricta** (Bruguière)

Pinecrest formation, Fish Eating Creek, Florida.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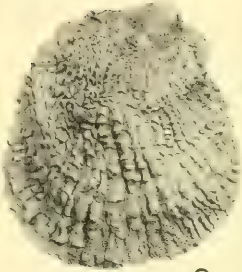
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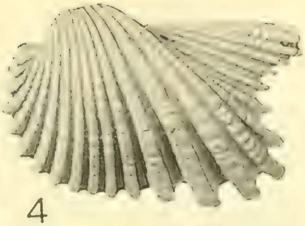
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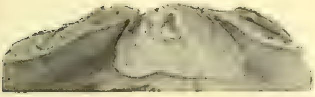
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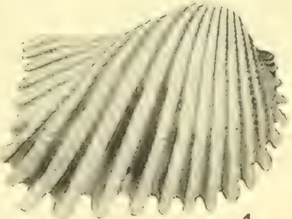
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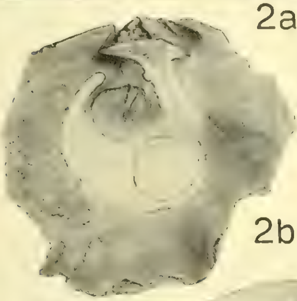
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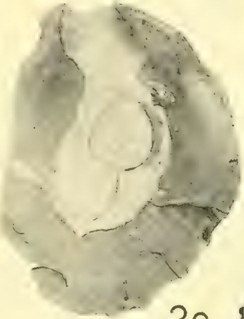
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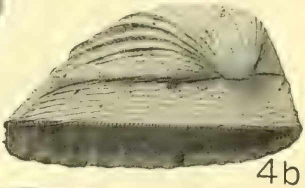
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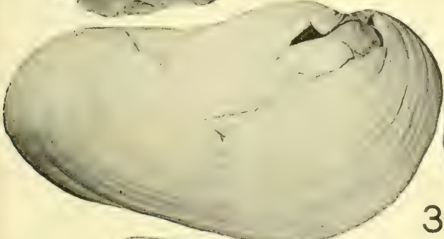
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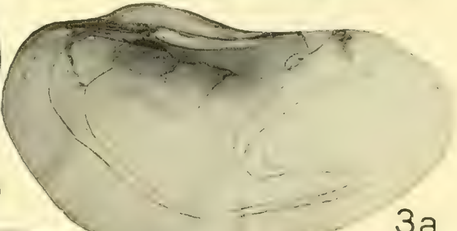
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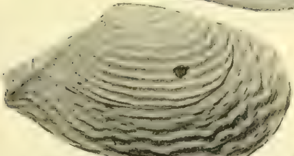
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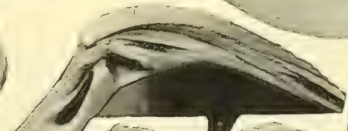
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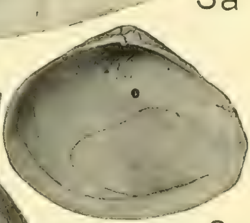
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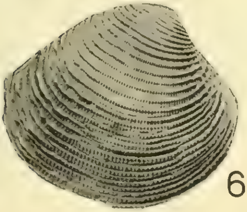
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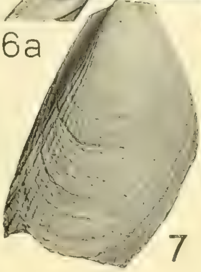
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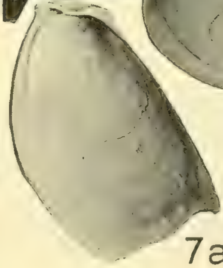
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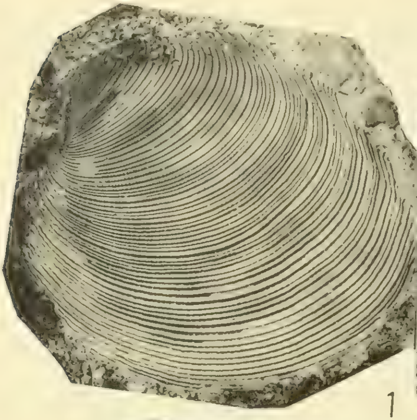
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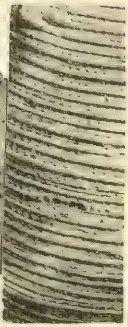
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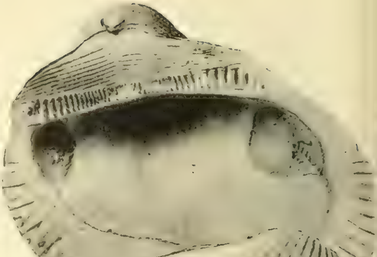
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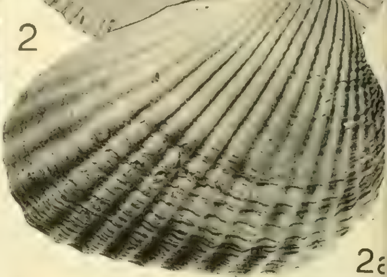
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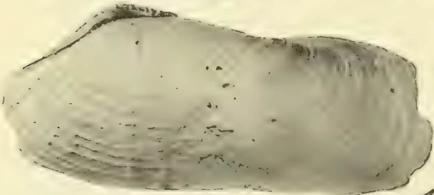
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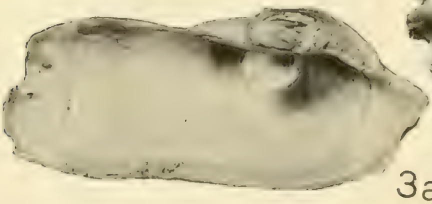
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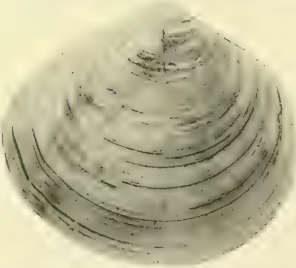
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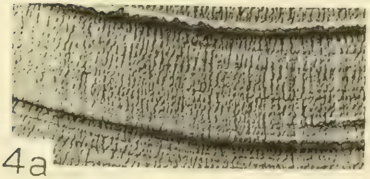
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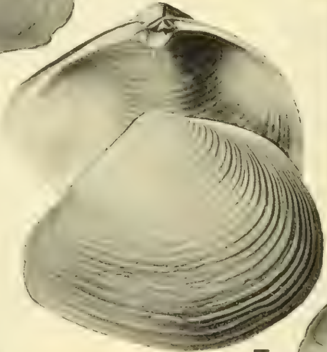
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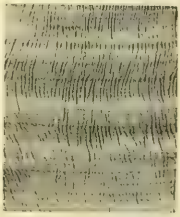
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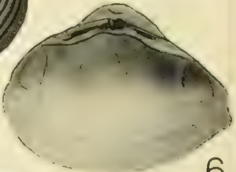
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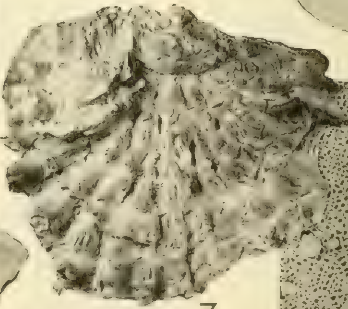
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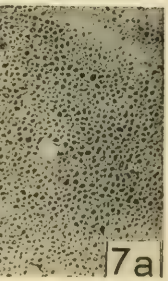
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EXPLANATION OF PLATE 78

Figure Page

1, 1a. **Periglypta tamiamensis,** new species 532

Impression in limestone, length 110 mm. Holotype, USNM 644642. Fig. 1a. Small section of surface to show details of sculpture. Tamiami formation. Sunniland, Fla.

2, 2a. **Anadara (Larkinia) sellardsi** (Mansfield) 528

Figures of the same valve, interior and exterior. Length 94.3 mm., height 84.6 mm., diameter 32.7 mm. Pinecrest beds, Pinecrest, Fla.

3, 3a. **Pholas (Pholas) memmingeri** Tuomey and Holmes 536

Figures of a left valve. Length 88.7 mm. Collection Miss Muriel Hunter. Pinecrest beds, Fish Eating Creek, Fla.

4, 4a. **Semele harveyensis** Mansfield 535

A right valve, length 57.2 mm., height 51.5 mm. Pinecrest beds, Fish Eating Creek, Fla. Fig. 4a. A section of surface magnified.

5, 5a. **Raeta undulata** (Gould) 533

Fig. 5. A single double valve specimen showing hinge and part of the interior of the left valve, and the exterior of the right valve. Fig. 5a. A section of the surface magnified to show minute sculpture. Pinecrest beds, Fish Eating Creek, Fla.

6. **Mulinia congesta** (Conrad) 533

Interior of a right valve, length 32 mm. Pinecrest beds, Fish Eating Creek, Fla.

7, 7a. **Pycnodonta haitensis** (Sowerby) 531

Exterior of a left valve, height 114 mm. Fig. 7a. A small section from the marginal band magnified to show cellular structure. Tamiami formation. Sunniland, Fla.

EXPLANATION OF PLATE 79

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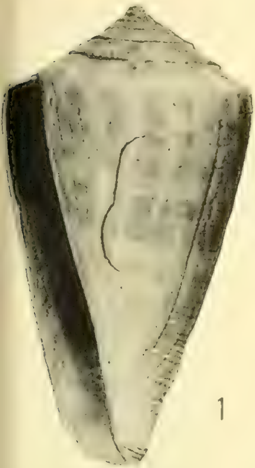
6.	**Dorsanum ? plicatile** (Böse) Length 48.9 mm. Miami Canal, Fla.	552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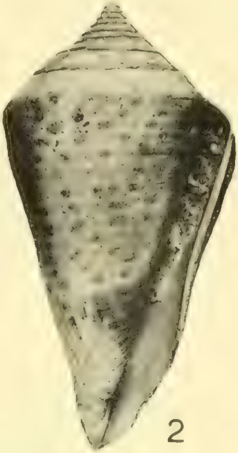
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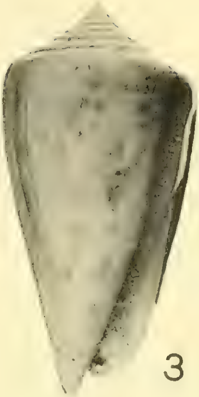
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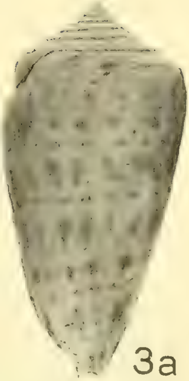
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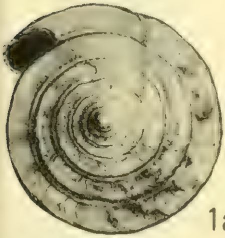
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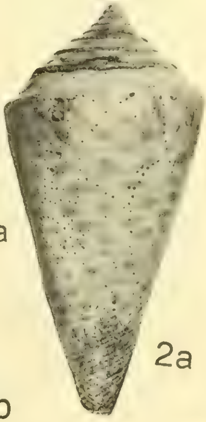
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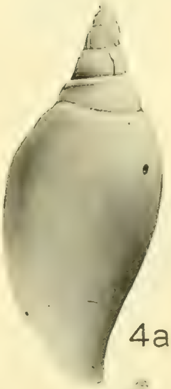
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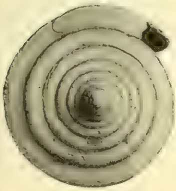
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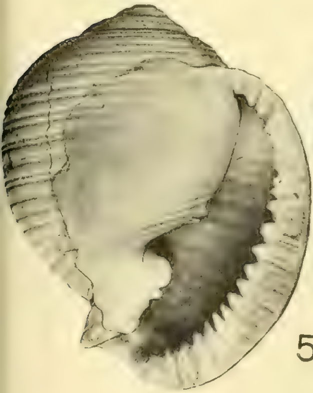
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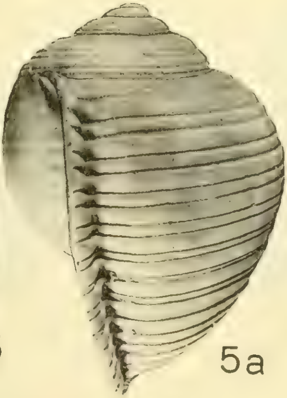
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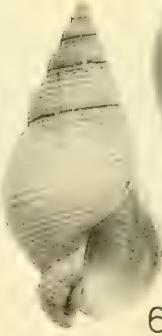
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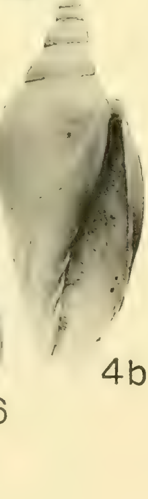
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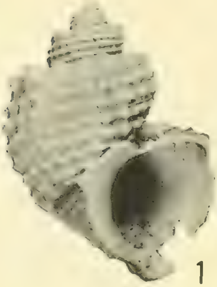
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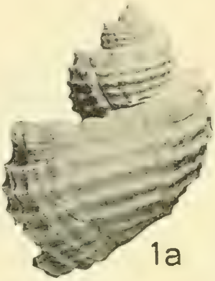
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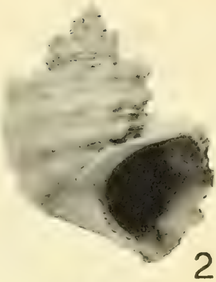
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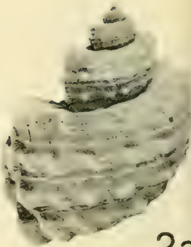
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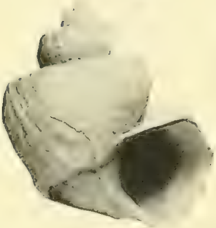
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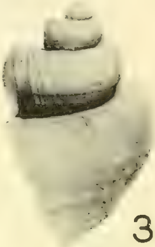
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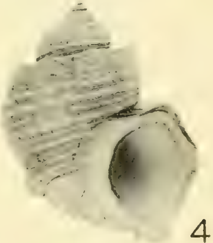
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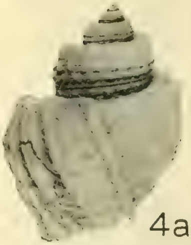
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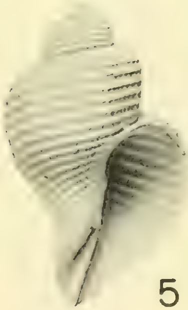
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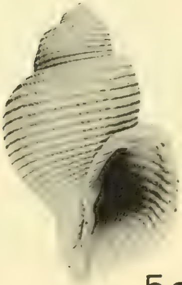
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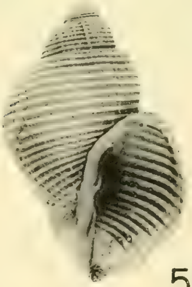
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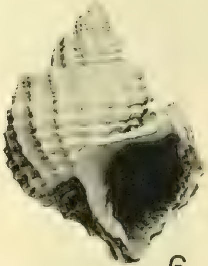
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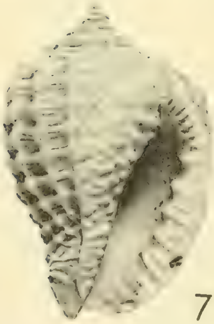
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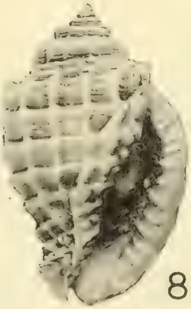
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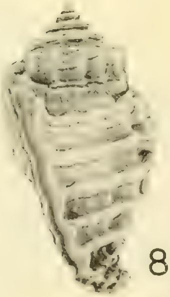
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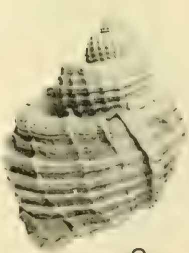
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EXPLANATION OF PLATE 80

Figure Page

1, 1a. **Trigonostoma (Emmonsella) betsiae,** new species 544

Ventral and dorsal aspects of the same specimen. Height 36.4 mm. Holotype, USNM 644649. Waccamaw formation. Crescent Beach Airport, S. C.

2, 2a. **Trigonostoma (Emmonsella) elizabethae,** new species 543

Ventral and dorsal aspects of the same specimen. Height 46.8 mm. Holotype, USNM 644648. Waccamaw formation. Crescent Beach Airport, S. C.

3, 3a. **Trigonostoma (Emmonsella) helenae,** new species 543

Ventral and dorsal aspects of the same specimen. Height 50.2 mm. Holotype, USNM 644650. Caloosahatchee marl. Harney Pond, Fla. Collected by Mrs. Helen O'Brien, Daytona Beach, Fla.

4, 4a. **Trigonostoma (Emmonsella) carolinense** (Emmons)...........................542

Ventral and dorsal aspects of the same specimen. Height 49.4 mm. Pinecrest beds, Kissiminee. Collected by Mrs. J. W. Donovan, West Palm Beach.

5-5b. **Cancellaria (Massyla) propevenusta** Mansfield 540

Fig. 5 Height 45 mm. Fig. 5b. Height 56 mm., Pinecrest, Fla. Fig. 5a. Height 44 mm. Indian Reservation, Fla. Hughes coll. USNM.

6, 6a. **Trigonostoma (————) druidi,** new species 544

Fig. 6. Height 33.5 mm. Fig. 6a. Dorsal view of same specimen, Holotype, USNM 644651. Miami Canal. Paratype, USNM 644652. Miami Canal, Fla.

EXPLANATION OF PLATE 81

Figure Page

1-1c. **Typhis (Typhinellus) carolinensis,** new species 551

Figs. 1-1b. Holotype, USNM 644655. Length 32.6 mm. Fig. 1c. Paratype, USNM 644656. Length 33 mm. Waccamaw beds. Crescent Beach Airport, S. C.

2, 2a. **Trochita floridana,** new species 563

Diameter 53.8 mm. Holotype, USNM 644659. Pinecrest beds, Fish Eating Creek, Fla. Collector Miss Muriel Hunter.

3, 3a. **Pterorhytis (Neurarhytis) marshalli** (Mansfield) 549

Length 32.7 mm. Waccamaw beds. Crescent Beach Airport, S. C.

4. **Pterorhytis (————) seminola,** new species 550

Length 45.8 mm. Holotype, USNM 644657. Florida State Indian Reservation levee.

5. **Olivella (Dactylidia) druidwilsoni,** new species 545

Apertural and back view. Length 13.5 mm. Holotype, USNM 655658. Pinecrest beds, Pinecrest at the 40 mile bend, Tamiami trail, Fla.

6. **Strombus williamsi,** new species 561

Back and apertural view. Length 230 mm. Holotype, USNM 644660. Pinecrest beds, Brighton facies. Indian Reservation levee, Fla.

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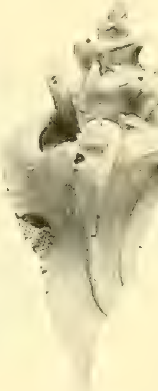
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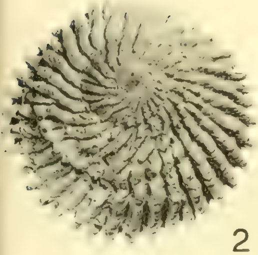
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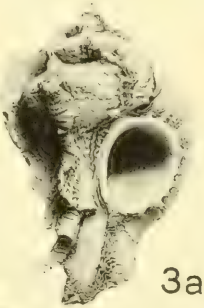
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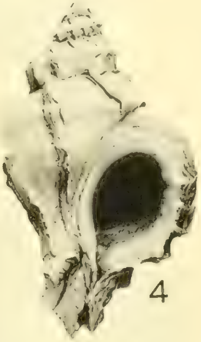
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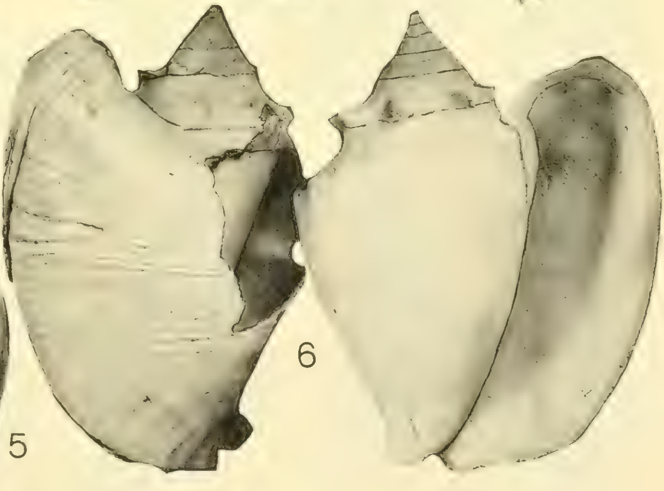
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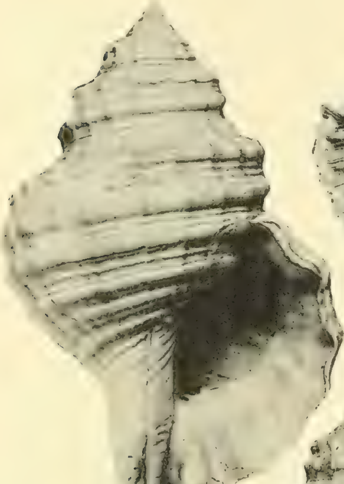
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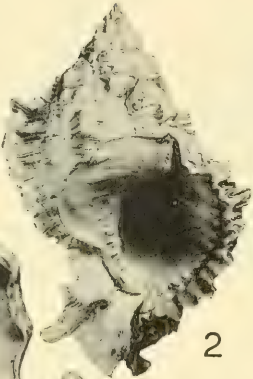
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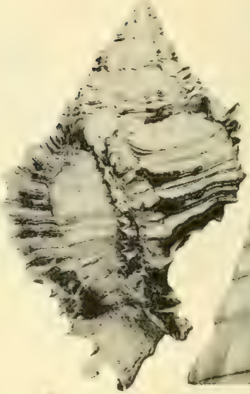

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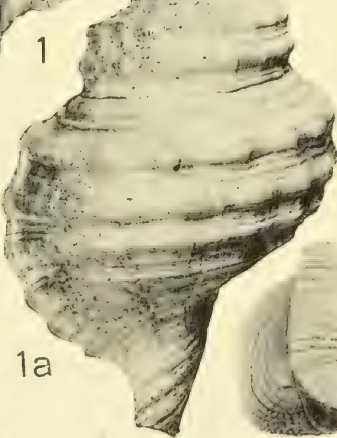
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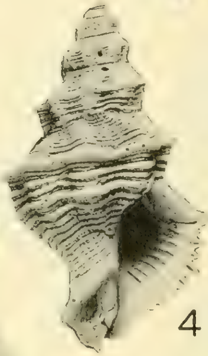
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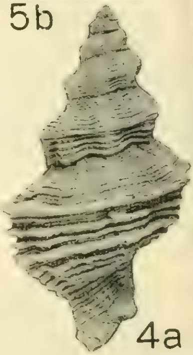
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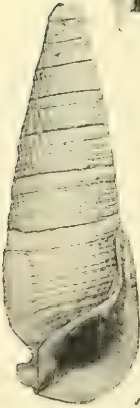
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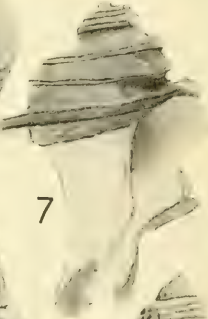
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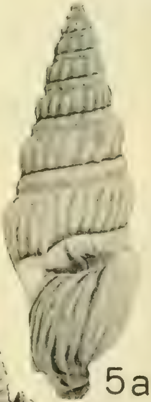
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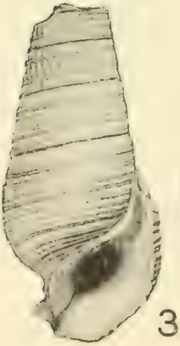
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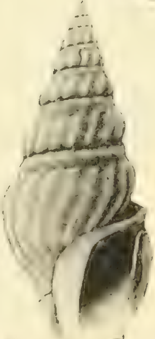
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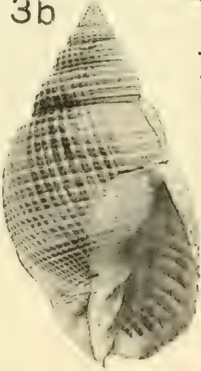
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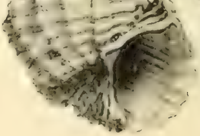
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EXPLANATION OF PLATE 82

Figure Page

1, 1a. **Cymatium (Linatella) valentinei,** new species 562

Front and back views, height 126 mm. Holotype, USNM 644661. Pinecrest beds. Brighton, Fla.

2. **Phyllonotus globosus** (Emmons) 549

Front and back views. Pinecrest beds, Indian Reservation, Fla.

3-3b. **Cerithium (Cerithioclava) dalli,** new species 565

Fig. 3. Length 70 mm. Holotype, USNM 644662. Figs. 3a, 3b. Length 63.9 mm., diameter 28.2 mm. Paratype, USNM.

4, 4a. **Coralliophila (Babelmurex) mansfieldi** (McGinty) 551

Front and back views, height 33.3 mm. Helen O'Brien collection.

5-5b. **Cymatosyrinx aclinica** Tucker and Wilson 537

Fig. 5. Length 51.5 mm. Fig. 5a. Length 61.6 mm. Fig. 5b. Nuclear whorls of fig. 5. Pinecrest beds, Pinecrest, Fla.

6. **Cancellaria (Cancellaria) rotunda floridana,** new subspecies 540

Length 80 mm. Holotype, USNM 644653. Pinecrest beds, Slough Ditch, Fla.

7. **Ecphora quadricostata umbilicata** (Wagner) 552

Fragmentary specimen, height, 47.6 mm. Pinecrest beds, Pinecrest, Fla.

8. **Trigonostoma (————) druidi,** new species 544

Height 27.2 mm. Paratype, USNM 644652. Pinecrest beds, Indian Reservation, Fla.

Explanation of Plate 83

Figure Page

1-1b. **Siphocypraea (Siphocypraea) carolinensis carolinensis** (Conrad) 557

All figures of the same specimen. Length 78.8 mm., height 34.7 mm., diameter 50.2 mm. Natural Well, Duplin County, N. C. ANSP 18859. Coll. Mr. Charles R. Locklin.

2-2b. **Siphocypraea (Siphocypraea) carolinensis floridana** (Mansfield) .. 558

All figures of the same specimen. Length 80.9 mm., height 36.2 mm., diameter 45.3 mm. Pinecrest, 40 mile bend, Tamiami Trail.

3-3b. **Siphocypraea (Siphocypraea) carolinensis transitoria,** new subspecies 559

All figures of the same specimen. Length 81.6 mm., height 37.4 mm., diameter 51 mm. Pinecrest beds, Brighton, Fla. Holotype, USNM 644663.

4-4b. **Siphocypraea (Siphocypraea) problematica** Heilprin 560

All figures of the same specimen. Length 78.2 mm., height 36.8 mm., diameter 46.2 mm. Caloosahatchee marl. Harney Pond, Fla. Olsson collection.

5-5e. **Siphocypraea (Siphocypraea) carolinensis hughesi,** new subspecies 559

All figures of the same specimen. Length 65.6 mm., height 30.3 mm., diameter 46.7 mm. Pinecrest beds. Slough Ditch, Fla. Holotype, USNM 644664. Coll. Mr. T. Hughes.

6. **Siphocypraea (Siphocypraea) chilona** (Dall) 560

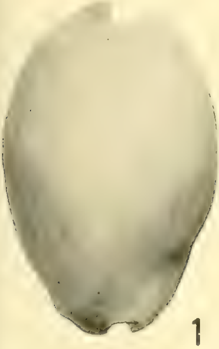
Longitudinal section to show inner whorls. Length 51 mm., height 32.6 mm., diameter 41.7 mm. Chipola Beds, 10 Mile Creek, Fla. Coll. Mr. Charles R. Locklin. USNM.

7. **Morum macgintyi** Maxwell Smith 556

Height 25 mm. Holotype, McGinty collection, Boynton Beach, Fla. Clewiston, Fla.

8, 8a. **Morum (Oniscidia) obrienae,** new species 555

Ventral and side views. Height 29.7 mm. Holotype, USNM 644654. Caloosahatchee, Fort Denaud, Fla.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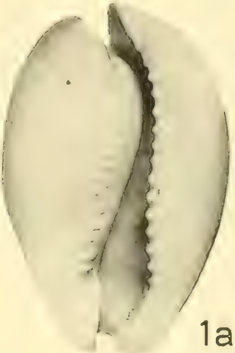
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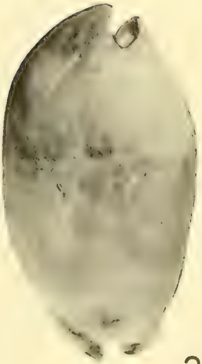
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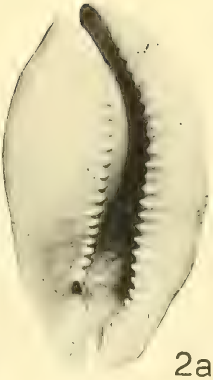
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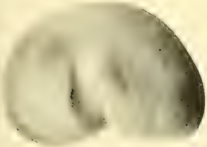
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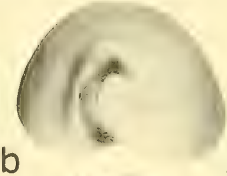
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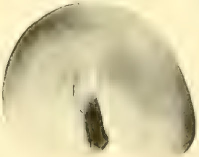
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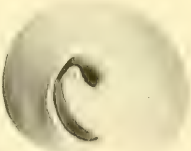
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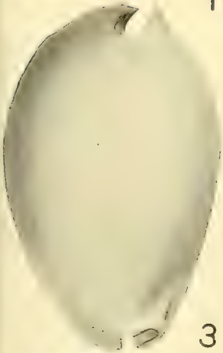
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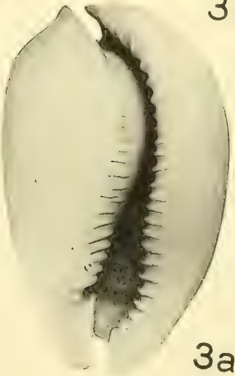
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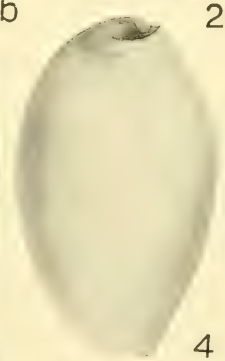
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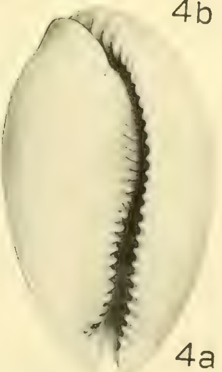
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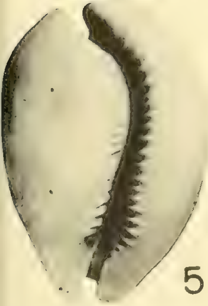
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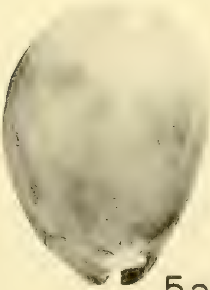
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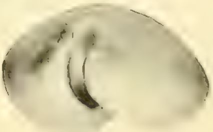
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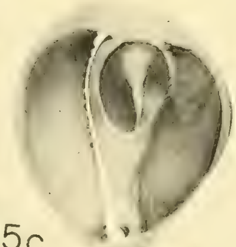
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